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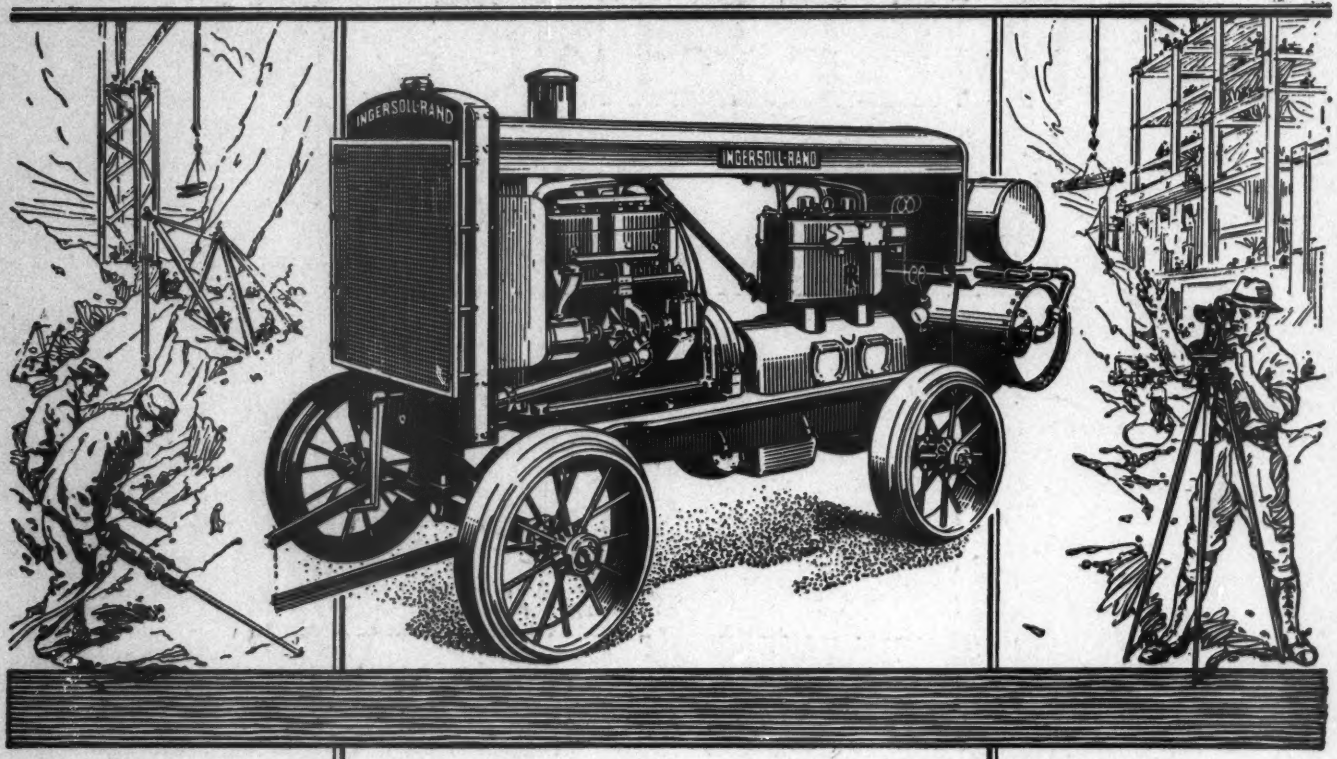

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XII FEBRUARY, 1931 NUMBER 1

A Two-Hundred Inch Astronomical Mirror

BY JOHN W. HAMMOND

Historian of News Bureau, General Electric Company

PROGRESS in Astronomy has depended largely upon the precision of measurement and the penetrating power of the available telescopes. The mathematical background of this science has always been perfected long before the actual measurements, for which the calculations were made. As a consequence each new advance in telescope design has brought with it a host of new conceptions of the physical universe. While the greatest existing telescope has a penetration of 750 quintillion miles, the limitations of such an instrument are sufficient to make the confirmation of many present theories of celestial measurement impossible.

Telescope design has been impeded by physical conditions which until recently were considered insurmountable. Generally speaking, the penetrating power of a reflecting telescope depends upon the size of the mirror which gathers and focuses the light. Such a mirror must be ground with the most exact precision in order to prevent distortion and error. In large sizes, however, the physical characteristics of the glass are such that preservation of the exact initial adjustment is extremely difficult, due to the weight of the mass of glass and to changes in temperature. As a result of these factors the magnitude of reflecting telescope lenses has been limited. The 100-inch mirror in the telescope at the Mount Wilson Observatory in California is, at present, the largest in the world.

Professor Elihu Thompson, inventor and perfector of the new process of fusing quartz which will make the 200-inch telescope possible.

Fabrication of the Existing 100-Inch Mirror

When this mirror was produced, the whole world of astronomy looked on, as it were, with fascination and breathless interest. It was an unparalleled undertaking to pour and grind and polish such a great disk of glass. So difficult did it appear in theory that few glass workers cared to attempt it. None in this country could be induced to accept the order. The astronomers finally found an establishment abroad that would aid them in the task — the Saint Gobain Glass Works in France.

The glass for the mirror was melted in three large pots, and then poured into a mould. The melting was in itself a long process, but the annealing required months. The glass was cooled very gradually, accompanied by many anxious days, to prevent it from going to pieces because of uneven expansion and contraction. The cooling finally completed, a still more delicate and tedious process was entered upon — that of grinding and polishing the face of the disk to work it into a slightly concave surface and then to shape this surface with the utmost accuracy to the form known as a paraboloid of revolution, permitting the light of a distant star to be brought to a single point.

This shaping and polishing of the glass to attain an accuracy expressed in millionths of an inch is a most difficult operation. The polisher, moving gently over the surface, causes the glass after a time to become heated and distorted. This is enough to suspend all further work for the day. The mirror is forthwith "put to bed" under five inches of felt. The following day, after a careful inspection, the polishing is resumed and carried a little further, until the glass is again heated to a dangerous degree. This went on for two years before the mirror was completed and ready for mounting in the telescope.

Proposed 200-Inch Mirror

And now there is proposed a mirror not one hundred but two hundred inches in diameter! It will be just twice as large as the present largest, which was produced with such pains-taking labor, over so long a period of time, and amid such constant hazards.

The funds for the new telescope have already been provided by the International Education Board, of which John D. Rockefeller, Jr., is the founder. The money is to be expended and the telescope is to be owned by the California Institute of Technology. The telescope is to be operated in close cooperation with the Mount Wilson Observatory, but will be located at an entirely new site.

The question of the mirror naturally led to much earnest discussion among the astronomers interested in the project. Glass was by no means ruled out; several new and ingenious methods of making a glass mirror, which would have to be as large in area as the

floor of a good sized living room, were brought forward. But these have been laid aside, for the time being, at least, in favor of a plan advocated by Professor Elihu Thomson, director of the Thomson Research Laboratory of General Electric, one of America's arc-light pioneers and one of the most distinguished scientists in this country.

Experiments With Fused Quartz

Professor Thomson proposed to construct the mirror of silica glass, or fused quartz. The great fundamental advantage would be that quartz contracts and expands only very slightly indeed under changes of temperature sufficient to crack glass almost instantly. Consequently the annealing process would take only weeks, instead of months; the grinding and polishing could be carried on continuously without the incessant interruptions caused by the undue heating of the substance worked upon; and the mirror, once completed and in use, would not have to be constantly safeguarded from changes in the surrounding temperature, as is necessary with glass mirrors.

Although Professor Thomson is a world authority on fused quartz and has studied and worked with it for thirty-five years, new problems were encountered — as was to be expected — the moment such a huge slab of fused quartz as required for the mirror of this telescope was seriously undertaken. None realized this more than Professor Thomson himself.

By no means did he intend to launch directly upon the fusing of the 200-inch disc. Instead he proceeded first to fuse small slabs, beginning with pieces eleven inches in diameter and then going on to discs twenty-two inches across. Specimens of both sizes were successfully produced, submitted to the astronomers, and pronounced entirely acceptable.

Model of a proposed mounting for the 200-inch telescope An idea of its size may be obtained from the figures of men standing beside it.

Making the First Discs of Fused Quartz

The process followed in these earlier discs was to first melt a base slab, or blank, in an electric furnace at a temperature well over 3,000 degrees Fahrenheit; next to deposit evenly over the face of this blank a surface coating of quartz of very high quality. This quartz, in powdered form, was fed through an oxygen-hydrogen burner at a temperature of approximately 4,000 degrees Fahrenheit. The powdered quartz was instantly melted in this intense heat, and flowed upon the face of the blank, "freezing" as it cooled into a clear, smooth surface coating, as transparent as glass itself.

The twenty-two inch disks were produced a year ago. Since then the Thomson research laboratory, under Professor Thomson's working assistant, A. L. Ellis, has been preparing to produce the first of the really large discs, a sixty-inch slab, which would be a foot in thickness and would have a weight of several tons. New problems were encountered as the plans progressed, chiefly because of the increase in size.

It was recognized from the outset that a special building would have to be erected to contain the furnace chamber, the shop crane of special form and the various auxiliary apparatus. This structure has now been put up and equipped. It consists of prepared sheet metal bolted together in sections so that it can be taken apart with little labor and enlarged or otherwise altered. It is, in effect, a portable shop building. The electric crane which it houses has a capacity of 135,000 pounds.

Plans for Producing a 60-Inch Disc

In the center of this building has been built a furnace pit approximately twenty feet in diameter, and within this pit is now about to take place the melting and fusing of a disk of quartz sixty inches in diameter, which will be a true forerunner of the final 200-inch disc, although one more intermediate step will first be taken, that of producing a 100-inch disc.

"The work has thus far proceeded only a relatively short distance," said Professor Thomson, in describing the enterprise. "Mirror blanks suitable for use in astronomical telescopes up to about two feet in diameter are produced and producible. These have all the desirable qualities which, of course, will be those of the great mirror.

"We cannot speak of taking only months to produce the large mirror; we must speak of years. It may be two or three years before the large mirror is turned out, but every product of our work is in itself an acquisition for astronomy, whether it be a two, three, five, or six-foot mirror — and we shall go to our goal by steps. Every one of these interim products will be a useful and desirable thing for the astronomer; in fact, the construction of the two-hundred-inch mirror involves the production of at least two or three others of lesser size to be used with it in several combinations.

"The mounting and use of the great mirror will be the same, except for a great enlargement of scale, as it would be with a glass mirror, but there will not be the disadvantage of having the accuracy of the work disturbed by changes of temperatures. The fearsome process of using the sun itself as the object of investigation, for example, will not cause the trouble with a mirror of fused quartz, that it would with a glass mirror."

(*Continued on page 26*)

Obsolescence in the Iron Industry

BY RALPH H. SWEETSER

Consultant in Blast Furnace Practice

A LARGE part of the price paid for progress in our American type of industrial civilization is obsolescence; obsolescence of machinery, of buildings, of whole plants; obsolescence of processes, of methods, of systems; obsolescence of highways, of waterways, of railways, of a whole network of transportation. In his address before the Ohio Foundries Association in Columbus, Ohio, Nov. 13, 1930, Frank W. Jackson, Assistant Vice President of the American Appraisal Company said "Obsolescence is THE important element of depreciation. It may be divided into ordinary obsolescence resulting from the gradual changes occurring in the progress of the art, provision for which is usually made through depreciation allowances; and extraordinary obsolescence resulting from radical and unusual changes in the design or use of equipment, losses for which should be taken as they occur. I wish to further segregate that part of obsolescence which may be termed lack of utility."

The iron and steel industry has been especially subject to ordinary and extraordinary obsolescence, and has sometimes suffered from obsolescence on account of lack of utility. In addition to these forms, there is in the steel industry still another form of obsolescence that might be called geographical because it involves location, distances, transportation, and freight rates. This last form of obsolescence is sometimes tinged with political factors.

Smelting Methods

The whole iron and steel industry is based on a unit of iron and a unit of heat. Usually the iron is smelted from the oxide ores of iron in an iron blast furnace, forming "pig iron" which becomes the base metal for all the many kinds of iron alloys and steel products. The fuels that have been used in America to obtain the heat required for this smelting of iron ores are charcoal, anthracite coal, "stone" coal, beehive coke, by-product coke, and, to a very limited extent, electricity.

Charcoal was, by nature and by propinquity, the first fuel to be used for making iron. Its inherent purity, with practically no ash and no sulphur, made it an ideal fuel for the smelting of iron ores; and the pig iron so produced was of such superior quality that even today the charcoal pig iron produced in certain wooded sections of our country commands the highest scale of prices. But the quantity of charcoal iron produced in the United States has gradually dwindled to less than a third of one per cent. of the total pig iron made in 1929, or only 138,193 tons out of a total of 42,613,983 tons (including ferro-alloys). The height of the charcoal iron industry in the United States as to total tons produced was in 1890 when the total charcoal pig iron made was 628,145 tons, which was only 6.82% of all the pig iron made that year compared with 46.49% of the total pig iron made in 1854, the last year that the tonnage of charcoal pig iron exceeded anthracite pig iron. Anthracite pig iron also reached its zenith in 1890 with a production of 2,186,411 tons, which was 23.75% of the total.

In the year 1855, anthracite pig iron passed charcoal with a total of 340,952 tons and held the lead until the year 1911 when the anthracite blast furnaces made only 229,575 tons, a little less than 1% of the total iron made that year; the charcoal iron was 278,676 tons, just a little more than 1% of the total.

If charcoal was able to regain supremacy over anthracite after 56 years of being in second place, is it possible for anthracite to come back at all after dropping out entirely as a blast-furnace fuel? In 1914, there was a total of only 1895 tons of pig iron made with anthracite alone; in 1915 there was none, and only 84,753 tons made with a mixture of anthracite and coke, with a total consumption of 36,216 tons of anthracite coal as blast-furnace fuel.

Growth of the Iron Industry

One hundred years ago, when the population of the United States was a little less than 13,000,000 people, and the consumption of pig iron was only 29 pounds per capita, the iron industry was scattered all along the Atlantic Coast and had extended west of the Alleghanies into the valleys of Western Pennsylvania, Ohio, Kentucky and Tennessee. In those days the blast-furnaces were all located near the iron ore mines, near enough for ox cart hauling of all the ore. The fuel was charcoal made in pits in the woods near the furnace and hauled in ox carts. The furnaces made from one to six tons of charcoal pig iron per 24 hours, and often much of this tonnage was cast direct into pots and kettles right in the cast house. In the Hanging Rock Region of Southern Ohio and Northeastern Kentucky the cast-house was usually called the "pot-house" because of the practice of making cast iron pots from the molten pig iron as it ran from the blast-furnace. Pig iron was sent to market in flat boats on the rivers, and by canal boats.

Then Came the Railroads

Ox-carts and canal boats were too slow for the assembling of ore fuel and flux when both the per capita consumption of pig iron and the population were doubled. Anthracite could be transported by rail cheaply and without danger of fire. It soon took the lead as a blast-furnace fuel and held it for over half a century. However, it was not until 1864 that the production of pig iron in the United States passed the million ton mark; by 1872 the anthracite pig iron had passed a million tons and the total pig iron made in this country was over two and a half million tons. In 1886 the output of pig iron was doubled again with a total of 577 blast furnaces in the country and again in 1898, making 11,773,934 tons of pig iron, but with a total of only 414 blast-furnaces; eight years later, in 1906, the output was again doubled (and for the last time to date) with a total production of 25,307,191 tons with a total of 429 blast furnaces, 340 of them active.

Raw bituminous coal, sometimes called "stone coal" was used in the blast-furnaces of the Mahoning and Hocking Valleys of Ohio for many years, and a little raw coal is still mixed with the coke used in the Jackson County blast-furnaces making "Jackson County Silvery" pig iron at Jackson, Ohio. The stone coal furnaces sometimes made as much as 25 tons of

(Continued on page 30)

Quantity Production of Wrought Iron

BY DR. JAMES ASTON

Consulting Metallurgist, A. M. Byers Company

SELDOM is any radical innovation made in our metal manufacturing processes. Time and economic necessity have reduced our methods of manufacture to a rather well defined procedure so that changes in practice have been few. For sixty years steel has been made principally in the Bessemer converter and the open hearth furnace; and, for approximately a century and a half, wrought iron has been manufactured almost exclusively in the puddle furnace. During these years some changes have been made in the manufacture of both iron and steel, but it was not until 1926 that there was devised a process which in operation, but not in principle, was a decided departure from customary practice. By this process, designated as the "Byers Process," wrought iron of exceptionally high quality can be produced in units comparable in weight to those from an open hearth furnace.

Placing the 6,000-pound bloom into a 900-ton electrically driven press for compacting.

Puddling Process

As is well known the puddling process is carried out in a furnace in which pig iron is converted into practically pure iron by the elimination of almost all of the elements, other than iron itself. This pure iron is at one stage granular, and when in this condition the grains are covered by a bath of slag so that each grain attains a slag coating. The grains are then worked by the puddler into balls and in this form the iron is removed from the furnace. The balls are put through a squeezer and the resultant "bloom" rolled in a mill. As the metal is rolled the slag that coated the grains is elongated into thin films which become interspersed in the iron in fibrous form.

Byers Process

In the Byers Process the procedure is analagous in principle, but the manner of achieving the same objectives is different.

Pure iron is obtained by melting pig iron in a cupola and then refining the molten metal in a Bessemer converter. This highly refined iron is carried in ladles to what is known as the "Processing platform" where it is carefully poured into processing cups in which is a bath of slag. This slag, which is of an exact composition, has been prepared in an open hearth furnace and tapped into the cups. As the molten iron falls through the liquid slag it solidifies into a granular form and, as in the puddling furnace, each grain takes on a coating of slag.

A peculiar phenomenon takes place while the grains of iron are falling through the slag. As the stream of iron strikes the surface of the slag, it breaks into minute globules in the the interior of which a gas instantaneously collects. While these globules are descending the gas pressure within them increases to a point where the hollow globules are completely shattered. This phenomenon, the bursting of the shells of the globules, permits the particles of metal to receive a complete coating of slag; and thus the action which in the puddling process gives wrought iron its peculiar merit, is carried out to even a greater degree in the Byers process.

After sufficient iron has been poured into the slag, the surplus slag is decanted and a ball similar in every respect, except weight, is found in the bottom of the cup. This ball, instead, of weighing 200 pounds as in the puddle furnace, weighs from 6,000 to 8,000 pounds.

It is apparent that the same reactions that are basic in the hand-puddling process are also basic in the Byers process, and that therefore, while the wrought iron produced by both methods is practically identical, the latter process makes possible a closer metallurgical and chemical control without quantity limitations or exhaustive and arduous labor.

The necessary steps in the "Byers Process" are as follows:

1 — Obtaining a supply of pure iron
2 — Obtaining a supply of slag
3 — Processing the iron in the slag
4 — Decanting the surplus slag
5 — Pressing the ball of wrought iron into a bloom

To carry out the first of these steps it is necessary that pig iron be melted and poured into a Bessemer converter in which the pig iron is converted into pure iron.

Obtaining a Supply of Pure Iron

In practice this step is at present performed by melting the pig iron in three cupolas and then transferring it in a ladle car to two, ten-ton converters. It is the intention at some future time to erect a battery of coke ovens and a blast furnace so that molten iron can be carried from the furnace direct to the converters.

Into the cupolas are charged pig iron, coke and limestone. The coke supplies the heat necessary to melt the iron; the limestone provides the necessary flux to form a slag. A special treatment insures a very thorough removal of sulphur. Air to burn the coke is supplied by three blowers. When the iron is melted it is tapped from the cupola into a ladle car and in this is transferred to the converters. Every car of iron is weighed.

After the iron has been placed in the converter, it is rotated to a verticle position and a current of air at approximately twenty pounds pressure is blown through the bottom of the converter which passes up through the metal. The air oxidizes the carbon, silicon and manganese in the pig iron and makes it practically pure iron. In about ten minutes, when this operation is finished, the converter is tilted and its contents allowed to flow into a hot metal ladle which rests on a car.

The car and ladle are then drawn by a cable to a position in front of what is known as the "processing platform." Here the ladle is lifted off the car by a crane and the metal poured into a processing ladle. This ladle acts on a specially designed car which is so constructed that it can impart to the ladle, when tilted, a forward and backward, as well as a lateral motion, which insures a very even and uniform distribution of metal. Four processing ladles on cars are available on the platform.

Before the third step can be performed, a bath of slag must be provided, into which the iron can be "processed."

Obtaining a Supply of Slag

Into two tilting open hearth furnaces slag forming materials are charged in such proportions that the product will be of a definite predetermined composition. These materials are melted and, when at the desired temperature, the liquid slag is tapped into large processing cups. Only enough slag is permitted to flow into the cups to obtain the depth of bath desired. The cups are carried on a car, several of which make up a train. Pulled by an electric engine, the train is drawn over a circular track to a point beneath the processing platform where the cup containing the slag can receive the molten purified iron.

Processing the Iron in the Slag

While the cup with its bath of slag stands below the processing ladle containing the pure iron, the ladle is tilted enough to allow a small stream of iron to flow into the bath. The action that ensues is termed "processing." When sufficient iron has been poured, the train is moved to a position near a large press where a crane raises the cup and decants the surplus slag.

Decanting the Surplus Slag

As the slag flows from the cup in which processing has occurred, the ball of pure wrought iron remains at the bottom. The crane then carries the cup to a gigantic press where the ball is made to fall onto a square platform section which forms part of the press.

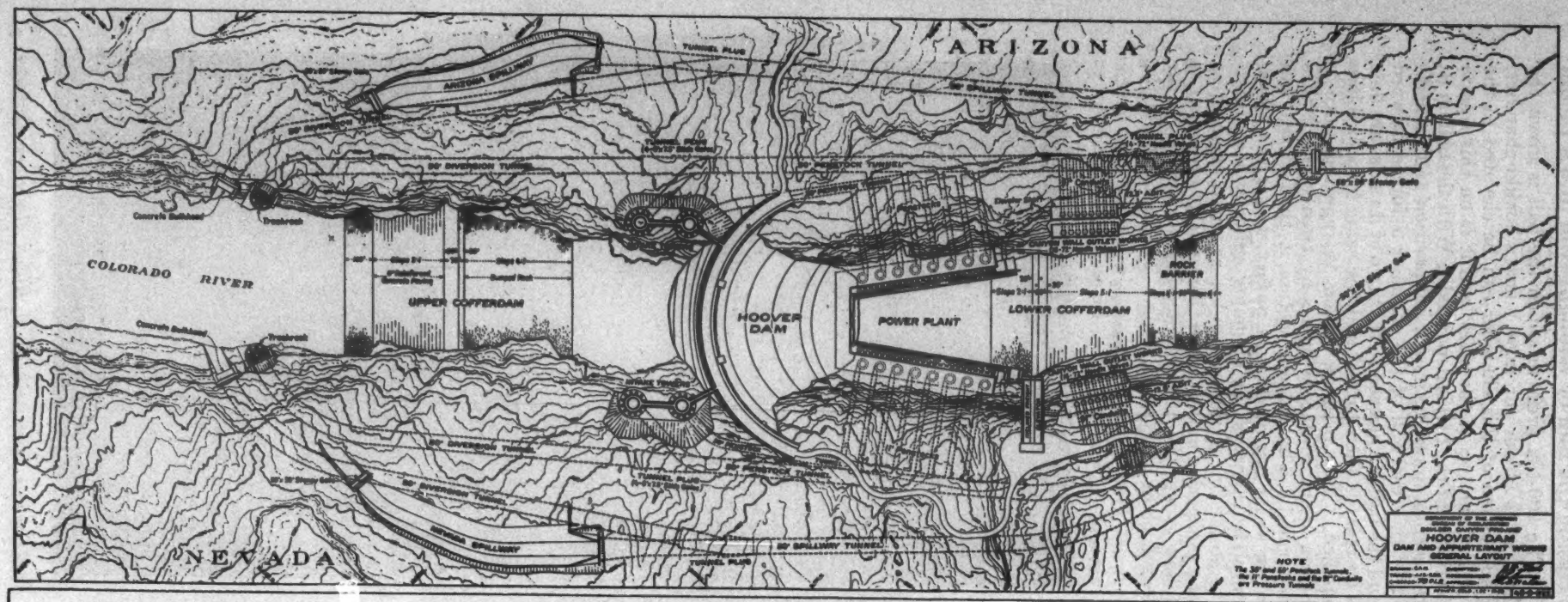
Pressing the Ball of Wrought Iron into a Bloom

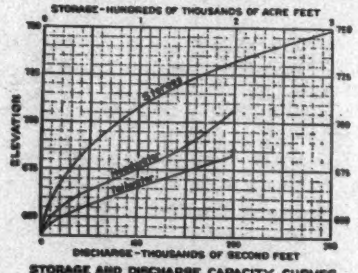
The 900-ton press in which the ball is given the form of a bloom (or ingot) has a boxlike chamber. The bottom of this chamber can be elevated to the level of the top of the sides, and it is on this square section that the ball is deposited. With the ball on it, the section lowers to its normal position and immediately the rear wall of the chamber is forced forward and the ball is squeezed so that two of its sides are flat. The mass is then turned and the same force is again applied. This pressing action is repeated until a bloom about seventeen inches by twenty-four inches is formed. The bottom section is then raised and when at its top position, a pusher shoves the bloom onto the rollers of the blooming mill approach table.

So far the entire process has required engineering of a pioneering nature, since there was no precedent to follow except the little engineering work done at the leased plant at Warren, Ohio. The reduction of the

(Continued on page 30)

Removing impurities in a 10-ton Bessemer converter before processing into wrought iron.





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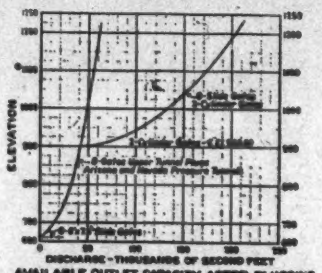
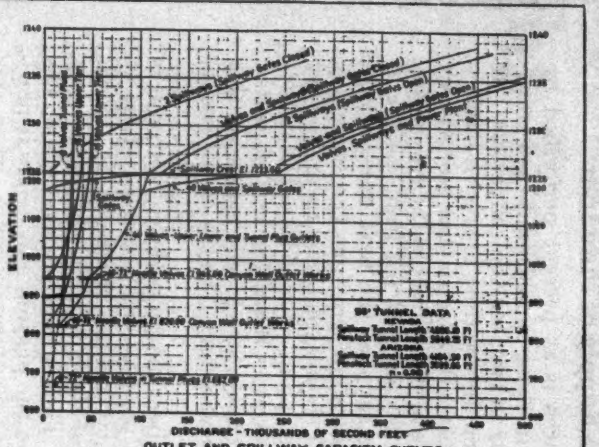
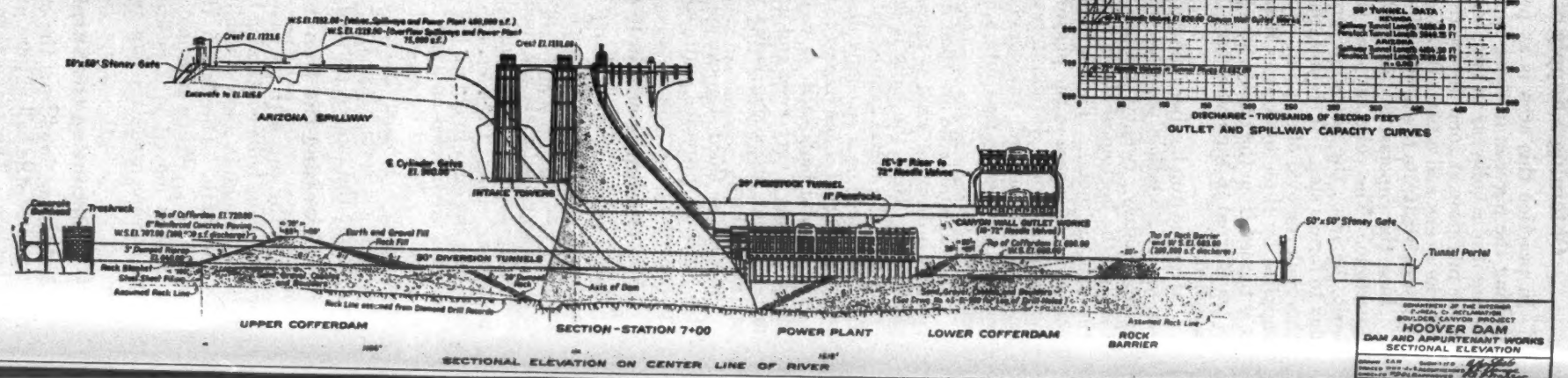


AVAILABLE OUTLET CAPACITY AFTER PLUGGING
DIVERSION TUNNELS



OUTLET AND SPILLWAY CAPACITY CURVES



SECTIONAL ELEVATION ON CENTER LINE OF RIVER

Hoover Dam

BY A. W. ADKINS

Bureau of Reclamation, Department of the Interior

HOOVER DAM is for the solution of the problem of flood protection for Imperial Valley, in California, which now is dependent on a 70-mile levee in Mexico on the ever-rising Colorado River delta. Although flood control is the primary purpose of the dam, the secondary functions, water storage for irrigation, and generation of power, are of great importance, and it is the latter that will make the project self-supporting. The Boulder Canyon Project includes the All-American Canal, the purpose of which is to meet the increasing demand for irrigation water for Imperial Valley, now supplied by the International Canal, the first part of which lies in Mexico, and perhaps to supply Coachella Valley.

The engineering of the project is being prosecuted by the Bureau of Reclamation under Dr. Elwood Mead, Commissioner, the design work being done in the Denver office under Raymond F. Walter, Chief Engineer, and John L. Savage, Chief Designing Engineer. Specifications for the dam, power plant, and appurtenant works, have been released for publication, and bids will be opened on March 4, 1931. The plans are subject to the approval of the Colorado River Board, consisting of Major General William L. Sibert, Chairman; Charles P. Berkey, Professor of Geology, Columbia University; Daniel W. Mead, Professor of Hydraulic and Sanitary Engineering, University of Wisconsin; Warren J. Mead, Professor of Geology, University of Wisconsin; and Robert Ridgway, Chief Engineer, Board of Transportation, City of New York.

Final Site Chosen

The site finally selected is in Black Canyon, 1½ miles from its upstream end, roughly 20 miles downstream from Boulder Canyon, or 185 miles downstream from the Grand Canyon National Park boundary. The nearest town is Las Vegas, Nevada, 25 miles to the northwest.

In August, 1930, the Los Angeles and Salt Lake Railway, subsidiary of the Union Pacific, started construction of a 23-mile spur from a junction 7 miles southwest of Las Vegas to Summit, the proposed site of the permanent town to be built by the Government. From there a 10-mile extension of the spur, as well as a construction highway approximately 8 miles long, both to be built by the Government, under contract, will descend over extremely rough country to the canyon rim above the dam site. The contractor for the dam will build a highway to start at this point, pass the top of an inclined freight elevator in the Nevada Canyon wall, by means of which construction equipment and materials will be lowered into the canyon, cross the top of the dam and eventually become a link in a proposed transcontinental highway.

The rock formations at the dam site are andesitic tuffbreccia and volcanic flows. Although somewhat jointed and faulted, the rock is well cemented and the faults, none of which are located so as to imperil the dam, are completely healed. High in the Arizona canyon wall undisturbed potholes crossed by faults show that no movement has occurred along these faults during the time required by the river to scour 900 feet into the rock, and the conclusion that present day earthquake danger is negligible is substantiated by geologic records. The rock is tough, durable and impervious, and considered excellent for tunneling as well as for foundation and excavation rock.

Dam 725 Feet High

The dam is to be of the arch-gravity type, with crest approximately 725 feet above lowest foundation rock, and it will be called upon to sustain a maximum differential head of 576 feet, this figure is based on present low water conditions. Stresses are determined by the trial load method as developed by the Bureau of Reclamation during the past six years, which is considered to be the most accurate method yet proposed for dams of this type. Briefly, the assumption of the method is that the dam may be represented by a grid of typical vertical cantilever elements and horizontal arch elements, an arbitrary number of each, and that the horizontal water load at any point may be divided between the two systems, the correct apportionment of the load at every point being that which will result in equal deflections of the two systems at conjugate points. Geometrical consideration shows that these radial deflections must be accompanied by twisting of the cantilevers. On the assumption that any load may be applied to a member of one system provided an equal and opposite load is applied to the member of the other system at the same point, the arches and cantilevers may be brought into geometrical agreement by the application of couples producing torsion in the cantilevers and reactionary couples producing direct bending in the arches, and a reapportionment of the horizontal water loads. This twist adjustment introduces the complications of the conditions for equilibrium of a particle, which must be investigated, and then tangential shear between the arches must be accounted for. In short, the analysis consists of determining, by a series of trials, that division of the horizontal water loads between the two systems which will allow the structure to remain geometrically intact.

In application of the trial load method in its present stage of development, the following factors are considered: weight of structure; water loading; hydrostatic uplift; temperature effect of both setting heat of concrete and variations caused by weather; compression, bending, and transverse and torsional shear in cantilever elements; compression, bending and transverse shear in arch elements; tangential shear between arch elements, and deformations of foundations and abutments.

Approximations heretofore considered safe are not completely trusted by the designers of this unprecedented dam, and comprehensive investigations are being conducted to determine the effect of saturation of the concrete near the upstream face, flow of concrete, Poisson's ratio, variations in the modulus of elasticity, and non-uniform variation of stress.

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Tailor-Made Steels

BY L. S. HAMAKER

Advertising Manager, Republic Steel Corporation

NEW departures in human activity usually are accompanied by corresponding increases in vocabulary, and the importance of each new line of effort is roughly indicated by the quantity and character of the words it adds to the language. In industry, this linguistic accompaniment of achievement chiefly takes the form of trade names. There are many instances of trade names becoming incorporated in the body of our language as generic terms.

A glossary of alloy steels recently printed in a leading trade journal contains nearly 200 new trade names, although alloy steel has assumed definite commercial importance only in the relatively recent past. Moreover this promises to be only a beginning, and it leads directly to the real significance of a new industry which seems destined in the immediate future to bring about truly revolutionary changes in modern life. Each trade name represents the development of a product meant to perform some specific function more efficiently and economically than the straight carbon steel it replaces. In a word, through the development of alloys, industry is fitting steel to the job, instead of fitting all jobs to one kind of steel as in the past. Custom-made steels will represent the prevailing practice in the new age of alloys.

In industrial research laboratories both here and abroad hundreds of metallurgists are carrying on studies to devise the specifications of new alloys to meet every specialized requirement for steel, and the versatility of alloy metals seems to have no limit. Alloy steels already are used in a multitude of products as diverse as jewelry and railroad freight cars. And every development means an addition to the growing body of metallurgical terminology.

Pouring alloy steel ingots. Fire clay "hot top" delays cooling at top and furnishes molten metal to fill internal cavities caused by shrinkage in the ingot as it cools.

New Alloy Names

Names like Enduro, Nitralloy, Carboloy, Ascoloy, Izett and Toncan, which today are merely unfamiliar combinations of the alphabet to the average layman, tomorrow will be as familiar as phonograph, or radio, or automobile. The past year having been marked by unusual activity in the introduction of new alloy products, the new year is expected to see the beginning of the ultimate consumer's education in their functions and importance.

Never in the history of steel making has there been the restless experimenting that is taking place today, and, by the same token, never have new developments appeared in such quick succession. Not only new products, but new processes replacing old in almost every department of production serve to keep the industry on tip-toe, forcing even the long established departments of steel making to discover short cuts and develop new methods.

Perhaps the most interesting product development in recent years is the so-called stainless steel, or iron, as the case may be. This branch of alloy production already is becoming a field in itself, with a wide range of analysis designed to meet almost all corrosion and high-temperature conditions. The adoption of stainless steel for the bright parts of automobiles, in many price classes, with the accompanying consumer advertising marks an important advance in public knowledge of what alloying can accomplish.

German scientists undoubtedly have taken the lead in laboratory development of alloy steels. According to F. J. Griffiths, President of Republic Research Corporation, four of the five major developments of this kind in the past fifteen years have come from Krupp of Germany. The most advanced types of stainless alloys produced in this country today are being made under license from Krupp. The contribution of American producers to these new developments has been to devise the technique of putting these highly specialized products into mass production. Thus it has remained for American mechanical genius to make these important metallurgical discoveries available to the average man.

Stainless Steel on Tonnage Basis

In the case of the stainless steel, manufactured in small quantities abroad and used for such trinkets as cigarette cases, jewelry and even dental plates, the ultimate development would have been a slow and laborious process. Its adoption for automobile trim in this country promptly put the industry on a tonnage basis and production almost immediately reached a volume undreamed of by its European originators, permitting wide-spread industrial use.

Again, according to Mr. Griffiths, every reduction of a cent or two per pound in the price of these higher cost alloys has resulted in a 10% widening of their market. Therefore the steel industry today is spending millions in laboratories and new plants in an unremitting effort to discover new ways of improving products and services through new applications of alloys. One company, for example, has gone to the extent of establishing a separate research corporation, so that pure research may not be hampered or limited by the requirements of current production.

Because of the very nature of alloys, tonnage figures do not have the same significance as in the case of carbon steels, since one of the primary purposes of the new special steels is the simultaneous reduction of weight and increase in efficiency. In the present stage of the industry, new developments and trends are of greater importance than tonnage. Still, the tonnage volume already has assumed sizeable proportions. According to the American Iron and Steel Institute, total alloy ingot production was 3,500,000 gross tons in the United States in 1928. This represented a 30% increase over 1927, as against a 15% increase for the steel industry as a whole. The alloy ingot tonnage for 1929 showed another substantial gain. The following table is a computation by Iron Trade Review of the distribution of alloy tonnage in 1929 by consuming groups:

Production of stainless steel. in a large electric furnace is an example of highly modernized methods of steel manufacture.

	Per Cent.
Automotive Industry	61.40
Miscellaneous	17.80
Machine Tool Industry	6.34
Oil Industry	4.07
Agricultural Industry	4.05
Construction	3.72
Export	1.38
Railroads	1.02
Shipbuilding	0.22

As the table indicates, the automotive industry uses more alloy steel than all other consumers combined and the rapidity with which this industry seized upon the new idea of adapting steel to the specific job in hand has been amply repaid in results. American automobile manufacturers have far outstripped their European competitors through the application of alloys.

New Alloys Aid Aviation

One of the greatest aids to the advancement of aviation has been the development of steel alloys and heat treatments to bring out the required physical characteristics. Stronger and lighter construction of both plane and engine have been realized to the extent that engines are now built of alloy steels that weigh less than two pounds per H. P. Some aircraft builders use as many as ten different alloy steels in the construction of planes. The chief obstacle in the way of the airplane's complete commercial success has been the fact that beyond a certain point increased size is accompanied by relatively smaller load carrying ability. Great progress is being made along the lines of reducing weight while actually increasing power and strength toward the end that only a small portion of the engine's energy will be needed to lift the plane itself, the balance being devoted to carrying profitable pay load.

More and more the older industries also are asking the steel manufacturer what alloy steels can do for them. The experience of the oil refining industry is a case in point. The high pressures and extremely high temperatures involved in the new cracking processes used in making gasoline made ordinary steels unsatisfactory if not actually dangerous for many kinds of equipment. In 1928 the average recovery of gasoline from crude oil, the industry over, was 41.3%. Some refineries, using special chrome-nickel alloys in cracking still tubes and other parts were recovering more than 60%. On the basis of 912,000,000 barrels of crude oil received by refineries that year, 275,000,000 could have been conserved had the entire industry used the new methods made possible by the new metals. More recent developments in refining presage a 100% gasoline yield from crude oil, a tremendously important factor in the conservation of our natural resources. Without some of the newly developed alloys these processes would be commercially impracticable.

For the first time in history, the high chromium-nickel alloys permit industry to design equipment in which steel parts operate at high pressures "in the flame" without injury to themselves. The effect such metals will have on various types of power generation

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Advantages of High Speed Diesels

BY MYRON S. HUCKLE

Instructor, Aeronautics Department, M. I. T.

THE problems of the high speed Diesel would furnish a discussion as lengthy as an exposition of its virtues. The knowledge which should now be disseminated is that the engine has a great many advantages, and that its problems are being rapidly solved.

A few words are necessary here to properly define the term "High Speed Diesel Engine." In producing a high speed Diesel to run at speeds of 1,500 to 3,000 revolutions a minute it is necessary to depart from the constant pressure Diesel cycle, and to approach the constant volume or Otto cycle. To distinguish these engines from the true Diesels there has been a tendency to call them compression ignition or fuel injection engines. Sometimes they are referred to as simply high speed oil engines. Many combinations of the previous terms are used, but the name "High Speed Diesel" quickly expresses the meaning intended and for that reason will probably persist.

Many engine companies are now producing, or are said to be experimenting with, high speed Diesel engines. The present emphasis in this experimentation follows the fact that the outstanding opportunity for the high speed Diesel lies in the aircraft field. Certain advantages will point to its potential use in wheeled vehicles, marine installations, auxiliary drives, etc.

Safety of High Speed Diesel Engines

Notwithstanding the low fuel consumption the safety features constitute the greatest advantages of the high speed Diesel. This is principally due to the use of non-volatile fuel, but also to certain other characteristics. There is no appreciable amount of vapor in Diesel fuel to distill off at ordinary temperatures and form explosive mixtures with the air. The liquid fuel will burn but slowly, and a small flame may be quenched by pouring sufficient fuel over it.

When an empty tank or compartment of an aircraft becomes filled with gasoline vapor and air in certain proportions, the slightest spark will ignite it, causing a terrific explosion. Atmospheric electricity may accumulate to cause a discharge, or a spark or hot wire in the electrical system may provide a source of ignition. The vapor mixture may seep out to meet the hot engine exhaust. Volatile fuel can be blamed for disasters like that which occurred on the Imperial Airways in the summer of 1929 when a loaded passenger airplane exploded over the English Channel, resulting in the death of everyone on board.

In the extreme case of ignition of the liquid Diesel fuel, its slow rate of burning and ease of extinguishing make a fatal accident from this cause almost impossible. Back-firing into the manifold, which has been a prolific cause of airplane fires both in the air and on the ground, is impossible in the Diesel engine. In addition, there is no vapor air mixture in a Diesel powered aircraft to become ignited from hot exhaust ports, electric wiring or the clash of steel on rock. In the worst case, a fire started by liquid fuel striking the exhaust ports is easily extinguished. As a last alternative one member of a party able to drag the others to safety would have several minutes before the fire could be spread to dangerous proportions.

The elimination of gasoline from hangars and shops gives an increase in safety which is far from negligible. In addition to ordinary means of ignition, radio waves induce charges in the metal airplane and hangar parts, which produce sparks sufficient to ignite gasoline vapor.

The safety of such engines in marine installations is also notable. Any leakage of gasoline in a boat runs into the bilges to accumulate. An explosion or fire on a yacht may be as serious as one on an aircraft. Passenger busses are not as seriously affected by danger of fire, but its elimination, especially in accidents, is worth striving for.

The transportation and storage of volatile fuels constitutes a source of danger which will be largely eliminated by the general use of Diesel fuel.

Lack of Radio Interference

The second safety feature is the positive elimination of all interference with radio. Successful aerial transport service at present is found to depend upon the degree of help which the pilot may receive from the ground. Any interference with radio beacons and traffic direction adds an element of danger. In the future radio intercommunication between airplanes and between airplanes and the surface systems must be provided for the business man and tourist. If perfect shielding can be developed for spark ignition engines, the cost, complexity, and danger of failure still remain.

Indifference to Weather

The Diesel engine is remarkably independent of weather conditions. It has no high tension electrical circuit, which is liable to fail in rain, snow or spray, and is thus free from short circuits. Having no carburetor, the Diesel engine is not subject to the danger of stopping or of loss of power due to back-fire, whenever a little water finds its way into the carburetor jets. Tests have shown that ten, twenty, or thirty per cent. of water emulsified with Diesel fuel causes no inconvenience. There is no drop in power, or increase in fuel consumption and the maximum explosion pressures are reduced.

Spray, rain or snow entering the air intake of the Diesel passes through the engine with no danger of clogging carburetor air vents. In other engines only by heating the carburetor engine manifold can jamming of the throttle and ultimate choking of the passage by ice be prevented. Heating reduces the volumetric efficiency and adds expensive plumbing which is subject to failure.

Only the failure of lubrication or weakening of the metal limit the operating temperature. There is no detonation or pre-ignition possible in the Diesel cycle.

One of the greatest safety features of the Diesel is the substitution of a small fuel pump to serve each cylinder in place of a carburetor manifold system and a complicated ignition system. The failure of one

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Bridges - A Historical Sketch

BY CLYDE MacCORNACK

General Manager, The Phoenix Bridge Co.

BRIDGES have been used since the earliest days of civilization. It is probable that the first bridge was a fallen log across a forest stream. The earliest attempts at bridge construction were no doubt prompted by an effort to imitate such a structure. In the earliest periods of civilization bridges reflecting some conception of the scientific principles of bridge construction may be found. Until about the middle of the nineteenth century bridges were not designed, but were constructed as a result of experience of a few daring builders who had a somewhat vague conception of the principles involved in bridge construction, combined with sound judgment and common sense. For several centuries these problems engaged the attention of scholars of the day, and little by little they discovered and harmonized principles governing the design of structures.

Preliminary Theoretical Work

The earliest record of any effort to analyze these principles is traceable to Galileo, who made an effort to formulate the principles of beam action. This was about the middle of the seventeenth century. Some two hundred years elapsed, however, before all of the fallacies were eliminated from Galileo's solution of the problem. This brings us down to about the middle of the nineteenth century. Contemporaneous with Galileo, Robert Hooke made studies on the elasticity of materials and discovered the law of proportion between stress and strain which still bears his name. It is interesting to note that at about the same time studies were being made by experiment on materials to discover their character and action under load, scientific analyses were being developed to solve the same problem.

There is another somewhat remarkable coincidence in the development of the science of bridge construction. In the period from 1850 to 1860 the French mathematician, Saint Venant, formulated our modern theory of beams. During that same period Squire Whipple first made the correct analysis of stresses in trusses. Prior to the middle of the nineteenth century there was not available correct information for the scientific design of bridges. It can therefore be said that this data marks the beginning of a new era in bridge construction. For the next forty years, until about 1890, there was a marked advance in the science of bridge construction, and also in our knowledge of building materials. The principles published by Saint Venant and Squire Whipple and their application to actual construction were further developed and perfected. Engineers began to be familiar with these principles and learned their proper application.

Railroads Bring New Impetus

This same period, from 1850 to 1890, also embraces the period of the most rapid growth of railway construction in the United States. The entire country was covered with a network of railways which may be said to represent the backbone of our present transportation system. These railways required bridges in great number. There was therefore ample opportunity for engineers and students of the principles of design to apply these principles in actual construction. The need for bridges also stimulated the study of materials for construction. The earlier bridges were built almost exclusively of wood and cast iron, while a little later wrought iron was made available for tension members. Many of these bridges were somewhat

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The Hell Gate Bridge. An example of modern bridge construction made possible by the use of modern steels and more exact knowledge of bridge design.

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Editorials

Our Bow

With this issue, the Managing Board of Volume XII of THE TECH ENGINEERING NEWS makes its official bow to the Institute. The retiring board has successfully upheld the traditions of high quality of material which has been one of the most rigid standards of the publication and, in giving over its keeping, tacitly places the burden of maintaining that standard for another year upon the entering board.

Although it is only eleven years old, THE TECH ENGINEERING NEWS has developed materially since the first four-page pamphlet was presented — half fearfully, but hopefully — to the student body. There have been no phenomenal changes or sudden advances; the growth has been steady but sure.

In keeping with this gradual development, the present Managing Board contemplates no radical changes in policy. It will try to steadily improve the magazine, making any changes required by circumstances and new conditions, but in the main, trying to place its contents upon an even higher plane of excellence. Believing that most students, although studying engineering, are not familiar with the finer technical points of any but their own specialized fields, the material is presented in a non-technical manner so that any reader may understand it. Only people who are intimately acquainted with their subjects are asked to write so that the material may be authentic. The articles are short enough to present the facts concisely, but long enough to give a complete picture. When student articles of merit are submitted, the board will gladly publish them.

To maintain this ideal will not be easy, but the present board pledges itself to do all in its power to do so.

"Anything But Engineering"

A prominent Boston engineer, at the head of many large undertakings, was once asked what he would recommend a young man contemplating becoming an engineer to study. His somewhat startling answer was, "Anything but engineering." He then went on to explain his statement. The technically trained man, he said, usually rose much more quickly in the engineering profession at first due to this technical knowledge. His progress thereafter became markedly slower and after awhile was at a snail's pace. The reason was his lack of a broad outlook upon life.

This was due to his highly specialized training. An engineering curriculum allows little space for extensive reading and study in the liberal subjects such as literature, philosophy, and the arts. It must of

necessity be crowded with technical matter related only to that phase of engineering which the student intends to enter. It gives a specialized grasp of material things but has little of the human values in it.

The more advanced positions open to the engineer are almost all largely administrative and concerned with handling and meeting many different people. To fill this position, the engineer must, in addition to being familiar with the technical aspects of his profession, be a keen student of human nature and have a broad enough background to meet on their own ground people coming from many different environments and having many different trainings. Most of them have little understanding of the technical aspects of his work. Their training has been entirely different. To meet these people and be able to speak a common language with them, the administrators must be many sided enough to have one side which will sympathize with theirs. To develop only his engineering side and neglect all others is a fatal mistake and will inevitably prevent the engineer from rising above the ranks of the highly-skilled technician.

Too many engineering students allow their work to run them instead of running it. They let their studies dominate all their time, become narrow, engrossed only in their books and slide-rules, becoming more and more specialized and losing all contact with the broadening, cultural subjects. They finally come to look down upon these self-same subjects as effeminate and not fit for the attention of masculine engineers. Their attitudes may cost them dominating positions later on.

It is the very widespread prevalence of this frame of mind which caused the engineer quoted at the beginning to recommend that a young man study anything but engineering. He had seen too many promising men stopped short by their blank ignorance of and indifference to those invaluable, broadening, human fields without a knowledge of which there is little hope that a man can fit into the more responsible administrative positions.

Shouting in the Darkness

"The Omnipotence of Science" sounds well on a sensational newspage, but to intelligent thinkers the phrase is nonsense. The present tendency by the public to deify the scientist and the engineer may be founded on well-merited appreciation of his value, but there are some extremes, especially in the daily press, which are embarrassing to say the least.

The recent meeting in Cleveland of the American Association for the Advancement of Science is a striking example. The reports presented by the masters of that great body were of exceptional importance and interest. They deserved the great amount of publicity which the press accorded them. But in what devious ways did the press treat the news! A few conservative journals, interested in presenting the facts as facts and not as glowing accounts of conquest, went to the expense of sending a special correspondent, who knew his business, to the convention. The result was perhaps less stirring to the imagination, but it was food for thought which could be relied upon not to produce indigestion. Other papers took the bare account distributed by the Associated Press, sent the facts to the rewrite desk, and let the over-fertile imaginations of copywriters do its worst The result sold the paper, but at the same time it did much harm to the cause of the Association.

This latter type of journalism has done much to foster the modern American idea that Science can do anything and everything it chooses to do. The vividly colored pictures of "Life on Mars" accompanied by "popular" dissertations on the social life of that planet by pseudo-scientists which appear weekly in the Sunday supplements have a very similar effect Perhaps it takes a slightly lower level of intelligence to appreciate this sort of trash, but in the long run the result is the same.

How different is the statement* of Professor Shapley of Harvard? His list of the ten major mysteries which have presented themselves to the astronomer is much less a confession of ignorance than one of intelligence and hope. The statement of the problem is clear and concise. The possible methods of solution and their probability are definite. Progress is made on schedule, on a work-a-day program; a less glamorous picture for news-writers to paint than the one to which the public is accustomed, but a much greater one.

Not a great deal can be done about it. So long as newspapers must make profits, they will sacrifice truth for glamour in the interests of greater circulation. But it should be expected that those who are closest to scientific work and its engineering applications should work under no such delusions. A self-satisfied group of workers eventually becomes unproductive. A little healthy dissatisfaction with things taken in a hopeful spirit will do wonders.

*See article "A Two-Hundred Inch Astronomical Mirror". Page 5

The following is the first of a series of biographical sketches of the great scientists whose names appear on the four pylons of the Great Court. Another one will appear next month.

Aristotle

384-322 B. C.

One of the most universal intellects of all time and a notable influence on science was Aristotle, a Greek who lived over three centuries before Christ. He was a pupil of the great Plato and the tutor of Alexander the Great. In appearance he is said to have been an insignificant little man with affected, foppish manners. When he lectured to his students at the Lyceum in Athens he strolled around so much that he was called the Peripatetic Philosopher. He was a close observer of the concrete and specific, believing what our senses reveal to us to be the real world. His observations as a speculative philosopher are strange mixtures of wisdom and the ridiculous. It was natural enough to err, for he was pioneering in science and often was hampered rather than helped by the beliefs of his time. It is difficult to conceive of a world without accumulated scientific learning such as the one in which he worked. The rule and compass were his only accurate instruments. Nearly all the facts on which the physical theories of modern science are based were then undiscovered.

In his later years Aristotle established his school, the Lyceum, which became a famous workshop, especially for biology and the natural sciences. Aided by Alexander's support, he had a host of men collecting for him specimens with which he built up the first great zoological garden. Alexander furnished the first example in European history of the large-scale financing of science by public wealth. Aristotle founded the science of biology, with important contributions to botany and zoology; anticipated by two thousand years Spencer's generalization that the more highly developed and specialised a species or an individual happens to be, the smaller will be the number of its offspring; and came very near to a theory of evolution, as is shown by certain of his comparisons of man with animals. His biological studies form the greatest monument ever raised to science by any one man.

By showing the art and method of correct thinking, Aristotle founded a new science-Logic. In astronomy he made some brilliant observations on meteorology but otherwise showed little advance over his predecessors. Another great achievement was the establishment of the science of embryology. He performed some novel experiments in genetics and raised several very modern problems of heredity. All of this work was apart from his very extensive research in metaphysics psychology, esthetics, ethics, political science, and economics. Surely this forms the most marvelous and influential system of thought ever put together by any single mind. He spent the last twelve years of his life collecting and coordinating this wealth of knowledge and completing his many publications and books. No other human mind has so influenced the intellect of mankind, for his works furnished the very mould of medieval thought. He ruled the intellectual world until Roger and Francis Bacon remade science with new instruments, accumulated observations, and patient experiments.

Engineering Notes

High Water Trestles are being used to enable automobiles to continue over a road that is sometimes flooded. Usually in regions where roads are apt to be flooded the state has to either provide a truck to pull the cars through the water or else maintain a higher level detour. The high water trestle eliminates the construction and upkeep of a detour.

Deep snow also interferes greatly with traffic on a road. Snow plows can quickly clear the roads but often cars become stalled on them hindering the removal of the snow. For this reason many highways are blocked to vehicles until they are cleared, thereby saving lives and property. Other hindrances to efficient traffic organization such as trees felled by storms, accidents, broken bridges, and detours require quick work by emergency gangs. Modern road organization is designed so as to be able to receive news of such mishaps in time to provide warning signs to other motorists, eliminating more serious accidents.

Courtesy, Engineering News Record

This trestle takes care of overflow conditions on this road

An All Purpose Gun Mount has been developed for the 75 mm. rifle. It is so designed that it can be rapidly transported over any terrain, set up in a minimum of time, and provides maximum flexibility of handling.

The carriage has four outriggers (which when in traveling position act as the trail of the gun) and is mounted on balloon tires. This latter provision makes travel possible even over very soft ground. When transported on its own wheels it can be fired from two positions. In the first, the wheels are left on, two outriggers act as a split trail, and the other two are placed under the carriage to take the firing strain off the springs. In this position it has a traverse of 90° and a possible elevation of 80°. In the other position, the wheels are removed, the gun pedestal lowered to the ground, and the four outriggers spread in the form of a cross. When set up this way, the gun has the same elevation and a 360° traverse.

In addition, it can be transported on a truck. This truck has dual ballon tires on three axles, which provide sufficient supporting surface for nearly all cross country travel.

For very soft ground, light steel tracks can be quickly placed around the rear wheels. The motor of the truck is sufficiently powerful to enable it to climb a 30° grade, carrying gun and mount. On a level road it can travel as fast as 45 m.p.h. A small duralumin crane is built into the frame of the truck. This is able to lower the gun to the ground or to reload it on to the truck. When unloaded from the truck, it is fired from the second of the previous set ups. However it can also be fired directly from the truck. In this case the outriggers are attached to the body of the machine and spread to the right and left. Four jacks, built into the body frame, are lowered to the ground to take the strain of recoil off the tires. When shooting from the truck, the gun has a 360° traverse.

With wide range of traverse and elevation of the new mount combined with the power, rapidity of fire, and ease of handling, the 75 mm. gun should prove very valuable against tanks and aircraft. Besides, its mobility fits in with the trend towards mechanization in all departments.

Tractor Motorcycles are a part of the equipment of a European militia. These machines are of novel design and enable the rider to travel across country no matter how rough it may be. Instead of a rear wheel, the motorcycle is driven by an endless tread like that of a tractor. The tractor drive is so pivoted that it can tilt forward or to the rear accommodating itself to the character of the ground. A heavily-braced triangular frame supports the tractor at a point far enough back of the seat so that its gyrations will not bump the driver.

While designed primarily for military use, the motorcycle may also be adapted to surveying parties which are forced to leave good roads in order to do their work. In test, the new tractor cycle has been found superior to horses which have always been used in traveling over rough country.

The Largest Generator Shaft for hydro-electric purposes in the world has just been made by an American corporation as a part of a contract for machinery for a power plant in Russia. This immense one-piece steel forging weighs 136,000 pounds and has a length of over 36 feet. This shaft will transmit 84,000 H.P. and will carry a vertical load of 1,000 tons. The coupling of this giant shaft is nearly 6 feet in diameter.

To this coupling the hydraulic turbine will be attached by means of a shorter shaft. The machine for which this shaft is to be used is to be shipped for installation in the Soviet Republic, where several

very large hydro-electric power plants are being equipped with American machinery.

An Automobile Turntable that swings a car around in the same manner as a railroad turntable provides a solution to the entrance of crowded apartment garages where the turning space is limited. A revolving platform large enough for standardized cars is used which can be controlled either by hand or electric power. For electric operation, a push button on a cord is suspended over the table in a position so that the driver can reach it without getting out of his car. Hand operation requires the swinging of the table which is so perfectly balanced that a child can operate the movement of both car and table. The table makes one-half revolution before stopping. A turntable along the same idea has been in use for several years by a prominent railroad company in turning their busses in a downtown New York City skyscraper.

The Vibrometer is an aid to analyzing and eliminating vibrations due to mechanical and electrical unbalance. It is a small instrument containing a neon tube and a source of white light, as well as a ground glass scale. The oscillation of the beam of reflected white light upon the ground glass shows the amplitude of vibration, magnifying it about 500 times.

The red neon tube is controlled by a "breaker head" causing it to flash once every revolution. Thus it makes a rotating member seem to stand still. In the accompanying illustrations is shown the vibrometer in recording position, and the reading for a 175 H.P. motor. The lighter band is the white light, the length of the band indicating the amplitude of vibration, while the two black rectangles in the upper half are the red beams. These two red beams indicate chattering and vibration; shades in white do also.

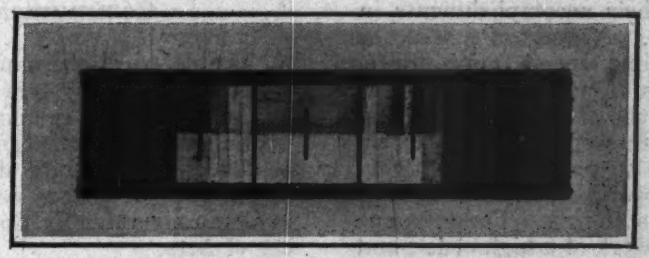
After repairing the motor the vibrometer showed a clearly defined white band with a steady red beam.

Courtesy, Machinery

The vibrometer in a position for recording vibration.

A Suspended Dome, 200 feet in diameter, is part of the designs of the Travel and Transport Building being constructed for the World's Fair in Chicago to be held in 1933. The dome will have a height of 125 feet, and will be supported by a system of suspension cables. These cables are hung from twelve steel towers placed around the circumference of the dome. The columns are arranged in four groups — three in each quadrant. Each set of three is designed as a separate structural unit so as to provide sufficient flexibility for changes in load. Each tower is 150 feet high and consists of a large I beam with two small ones with their flanges against its web. Trussing on the inner side gives it the necessary stiffness. From the top a system of backstays runs down to three concrete anchorages which are shared with the other two columns of its group. The base of each is built with a rocker bearing to permit a slight radial motion at the top. The supporting cables are attached to the roof by hanger rods at four points on each side of the center. Besides the six between the tops of opposite towers, there are two on the lines separating the quadrants. The ends of these are split and carried to the nearest towers. The wells are hung on struts between the columns of each unit, and the groups are connected by horizontal trusses which also support the huge portals.

The advantages claimed for this method of construction are that the high cost of erecting steel arch-rib work is eliminated, and the fact that the vertical supports and walls can be carried as high as the spring of the dome, thereby effecting economy in carrying the load.



Courtesy, Machinery

The above vibrometer reading indicates excessive bearing clearance.

A Locomotive Washer is operated automatically by the passage of the locomotives. An insulated section of track is provided, extending several feet on each side of the device. When the locomotive reaches this section, current passes, operating relays. One of these starts a small motor which swings the cleaner into position, and the other turns on water, steam, and, if desired, washing solution. The cleaner itself consists of two vertical pipes, one on each side of the track, curved over the track at the top when in position. When not in operation, the curved tops are parallel to the rails at a safe distance. By this apparatus, the services of several wipers are unnecessary, and the locomotives are kept cleaner. No trouble has been experienced with it during the time it has been in use.

An Electric Multi-Tool consists of an electric motor to which a number of attachments may be fitted. The weight is 5¼ pounds. It can be used for drilling, grinding, buffing, sanding, sawing, nut setting, screw driving, planing, valve grinding, reaming, under cutting, nibbling, shearing, and mixing. The various attachments to perform these operations are screwed to the nose of the device.

Departmental Notes

Department of Electrical Engineering

The Honors Group Plan

In the fall of 1925 with the consent of the Faculty the Department inaugurated a plan which aimed to provide an independent atmosphere of work designed to stimulate an attitude of intellectual courage and resourcefulness in students of appropriate mental capacity and personal qualifications, known as the Honors Group Plan. A description of this plan was published in THE TECH ENGINEERING NEWS in its April 1930 issue. At a meeting of the Faculty near the close of the last Institute year, the Department made its first formal report, based upon five years of experience with the plan. The experience showed that honors students have done notable work under the arrangement and have in a large measure developed those qualities which the plan aims to encourage. The interesting feature of the academic records of these students is that in general an upward trend is shown during the two-year period of honors study as compared with the records of other electrical-engineering students, or as compared with the records of the honors students prior to the period of honors study. However, the reason that the records have been valued by the students and gratifying to the Department is not on account of their excellence alone, but primarily because they were earned so largely by independent work.

New equipment installed in Machine-transients laboratory.

The total number who have been graduated as honors students now is 87. Since the first of these have been graduated but a few years, and since a large number have continued in graduate work, it is rather early to make a study of their accomplishments in their subsequent occupations. A study of this sort is contemplated when the time seems appropriate. However, a number of cases of notable accomplishment already have come to the attention of the Department. Each year, fellowships established by Gerard Swope, '95, for the purpose of encouraging graduate study, have been awarded to the two senior honors students of highest standing. These Swope Fellows have done graduate work of a high order, and have gone into important engineering employment.

Following the presentation of the Department's report stating the progress of the work, the Faculty voted to authorize the Department to incorporate the Honors Group Plan as a permanent part of its educational process, and to permit other departments to adopt similar plans should they so desire. In the Department of Electrical Engineering the plan now is in its sixth year of operation with a total of 22 honors students in the junior and senior classes. The Department is continuing its plan along the lines already laid down and endeavoring to render the functioning of the plan more effective. The object of immediate study is the status of the comprehensive examination given to honors students near the end of the senior year. Last year the comprehensive examination was for the first time made a requirement and administered by examiners invited from industry. It is hoped that the scope and weight of the comprehensive examination may become such as to have an effective influence upon habits of study throughout the entire two years of honors work.

Other Educational Processes

Other features of the Department's educational processes which continue to be carried out with success are the plan for sectioning in accordance with mental speed, which takes cognizance of the fact that different students learn with various degrees of ease and rapidity and endeavors to accommodate the nature of the instruction to the characteristics of the students; the series of orientation lectures, for sophomores, in which the educational processes of the Department and the relationships of the subjects of the curriculum are explained; and the colloquia, a series of discussions conducted by leading engineers invited from industry for the purpose of demonstrating the relationship of the scientific nature of the curriculum to actual engineering work. A particular development of the present term is the extension of the plan whereby the class-room work and the laboratory work is still more closely correlated by assigning the instructor for a particular section to both class-room and laboratory work.

Communications Option

The electrical-communications instructors installed the group address system used at the inauguration and at the graduation exercises last spring, and are now working on an installation for the main lecture room, 10-250. An elaborate demonstration was prepared for the popular science lecture, "Recent Developments in Communication by Radio," sponsored by the Society of Arts.

A Communications Laboratory of Acoustics has been established recently to supplement the existing communications-laboratory facilities. This laboratory is being developed to support both undergraduate and graduate work in the subject of acoustics as related to electrical communications. In this laboratory, measurement of actual motion in a sound wave has been accomplished by means of apparatus which does not disturb the wave. For use as a source of audio-frequency power, an electric oscillator has been developed which gives a wave form of unusually low harmonic content. In association with this a tuned vacuum-tube galvanometer has been developed with

(*Continued on page 29*)

STEPPING INTO A MODERN WORLD

Now they *manufacture* weather for telephone testing

A test illustrating work in the Bell Telephone Laboratories is made with the weatherometer. This device produces rain and sunshine to order, and determines the weather-resisting properties of telephone equipment.

This test indicates an interesting habit of the men engaged in telephone research. It is to get sure knowledge bearing on efficiency, economy, life and reliability of apparatus.

Information is sought continuously during the development of a design, in advance of manufacture and of course long before the equipment gets into use.

Men who delight in thoroughness of method find that *the opportunity is there.*

BELL SYSTEM

A NATION-WIDE SYSTEM OF INTER-CONNECTING TELEPHONES

Technology Review

PROFESSOR HARRY M. GOODWIN

Dean of Graduate Students and Head of the Department of Electro-chemical Engineering

Professor Harry M. Goodwin has been actively associated with the Institute for the past forty years. Under his direction the Department of Electrochemistry of which he is the Head, was established in 1909 and has since been developed into one of the most extensive courses in the Institute.

Professor Goodwin was born in Boston, April 18, 1870, and upon completing his earlier education at the Boston English High School in 1886, he entered the Institute as a student in Physics, Course VIII. After receiving his S.B. degree from the Institute in 1890, he took up graduate work in Mathematics and Physics at the Harvard Graduate School during the year 1890-91. While in attendance at Harvard he was at the same time acting as Assistant in Physics at the Institute under Professors Charles R. Cross and Silas W. Holman.

He began his extended and successful career as a member of the Institute Faculty in 1892, at which time he was made an instructor in Physics and granted leave of absence to continue his graduate studies abroad. He chose the University of Leipzig in which to work for his Degree of Doctor of Philosophy. While there he studied under Wilhelm Ostwald in Physical Chemistry; Gustav Wiedemann in Physics; and Carl Neumann in Mathematics. He completed his work in 1893 and then attended the lectures of Helmholtz and Planck and carried on research work in the laboratory of Kundt at the University of Berlin during the winter semester of 1893-94.

The present course in Electrochemistry owes its origin to the interest shown by Professor Goodwin in this type of engineering. After returning to the Institute in 1894, he was placed in charge of the work of instruction in the laboratories of General Physics whereupon he inaugurated lecture and laboratory courses in Chemical Physics and Electrochemistry. Realising the opportunities which this field of applied science presented to students, he proposed the curriculum of a four-year course leading to professional work in Electrochemistry. The course was first announced as an independent option in Course VIII and was the first of its kind to be offered in this country. The curriculum at once attracted the attention of the students and so greatly aroused their interest in the Course, that in 1909 the option was established by the corporation as an independent course — the present Course XIV, Electrochemical Engineering.

Professor Goodwin has contributed much to his profession in the way of writings. While directing the work of the Physical Laboratories he published a manual on "Physical Laboratory Experiments," covering the subjects in Mechanics, Light, and Heat, and a text on "Precision of Measurements and Graphical Methods," which served as the basis for the present course in this subject. He is also the author of a number of scientific papers published in the Technology Quarterly, the Physical Review, the Proceedings of American Electrochemical Society and Proceedings of American Academy in the fields of Physics and Electrochemistry. His first contributions were his Bachelor's thesis on "Some Studies on Binaural Audition" and his Doctor's Degree thesis on "Studien Zur Voltasche Kette."

He is a fellow of the American Academy of Arts and Sciences, being librarian of the Academy for the seven years 1923-1930, and Vice-President since that time. He is also a fellow of the Washington Academy of Sciences, the American Physical Society, and the American Association for the Advancement of Science, and a member of the American Electrochemical Society, the American Astronomical Society, and the American Mathematical Society.

For the past twelve years, Professor Goodwin has served as the Chairman of the Committee on Graduate Courses and Scholarships which has general supervision of the graduate work of the Institute. In 1926 the office of Dean of Graduate Students was established, and he was appointed Dean. By his unceasing efforts Professor Goodwin has contributed much towards the development of his profession and the advancement of one of the best courses of its kind in the country.

High Speed Diesels

(Continued from page 14)

fuel pump will cause the loss of but one cylinder and no interference with the others.

Simplified Controls

A great defect in present-day aircraft is the great number of controls. The Diesel possesses but one control, the throttle, while a carburetor requires in addition a spark advance control, a mixture control, an ignition switch, a fuel shut-off valve, a priming system, and sometimes a booster magneto.

General Operation

Many more advantages which increase the safety and facilitate the operation are possessed by the Diesel. Any mixture ratio from the leanest to the richest fires without fail in the Diesel, while the carburetor engine must have a fuel air mixture ratio between one to eight and one to twenty. Dirt or water in a carburetor jet and inattention to the altitude control, which are liable to stop a carburetor engine, do not affect the Diesel.

As gasoline has greater viscosity and inertia than the air, it lags behind the air in a sudden acceleration of the gasoline engine, giving a dangerous or low power mixture. In the Diesel the fuel is pumped directly into the cylinders. In addition, cooling the engine in a glide, or changing altitude cannot result in a dangerous mixture ratio in the Diesel. The Diesel engine is rated in power at a mixture ratio providing an excess of air. In an emergency an excess of fuel will burn the excess of air providing as much as twelve per cent. more than the rated power.

The Diesel fuel system has no float chambers which are dependent on their position for perfect operation. Instead of acquiring fouled spark plugs and smoky exhausts when an excess amount of lubricating oil gets by the worn piston rings, the Diesel burns the oil, providing an increase of power. The elimination of the intake manifold has disposed of distribution troubles. Regardless of the fuel, the temperature, or the technique of starting, a Diesel equipped with glow plugs will start at every attempt.

The Diesel fuel enters an atmosphere of approximately one thousand degrees F., and there is never any trouble from dilution of the lubricating oil, while the lower rate of fuel combustion results in a lugging ability similar to a steam engine under a heavy load. The Diesel exhaust gas contains a negligible proportion of carbon monoxide, thus eliminating the hazard of this gas.

Necessity of Fewer Engines

The elimination of detonation and pre-ignition points the way to larger cylinders and larger engines. One hundred and forty cylinders and five hundred and sixty valves with all of their gear, which is found on the DOX, presents an impossible maintenance problem. The use of even three small engines in place of a large one has been proved a false development. The Diesel is more satisfactory than the gasoline engine when used on a two-stroke cycle, as no fuel is lost in the scavenging air.

Economy

The second great advantage of the high speed Diesel is economy. The first reason for the better economy lies in the greater inherent thermal efficiency. The

familiar equation of air cycle efficiency: $ACE = 1 - \frac{1}{(R)^4}$ makes it obvious that the increase in compression ratio from around five to around fifteen will result in a great increase in the possible efficiency. As the Diesel operates most of the time with a great excess of air, the actual engine cycle will approach more nearly the ideal air cycle.

As to saving fuel, an increase in brake thermal efficiency of six per cent. is possible in the Diesel. When compared to the thirty per cent. efficiency of the carburetor engine, this means a twenty per cent. fuel saving. The Diesel will burn a mineral oil which is 70 per cent. cheaper than gasoline. It also will burn a wide range of animal and vegetable oils where mineral oil is too expensive. Waste lubricating and flushing oil from any garage can be centrifuged or decanted to provide an excellent Diesel fuel.

Insurance Reduction

With very little experience upon which to base their judgment United States Aviation Underwriters offer a reduction of 20 per cent. in the Fire Insurance Premium for aircraft equipped with Diesel engines. Diesel fuel will eliminate the six per cent. evaporation loss which is the average in the transportation, storage and use of gasoline.

The saving of fuel in an aircraft has a double advantage. Beside the saving in fuel cost, increased performance results. It appears from the work of Ricardo that a high speed, 2-cycle Diesel may be built to weigh no more than a gasoline engine. Twenty per cent. saving in fuel consumption would allow an increase in the useful load of the DOX of five hundred pounds on a ten-hour flight, a very substantial increase in pay-load.

Range

A four hundred and fifty H.P. airplane could, by substituting a Diesel engine, carry a useful load of about twenty-six hundred pounds, on a sixty-five hour flight, or about twenty per cent. increase in range or endurance could be expected. 400 BHP x (.5-.4) pounds x 64 hours = 2,600 pounds.

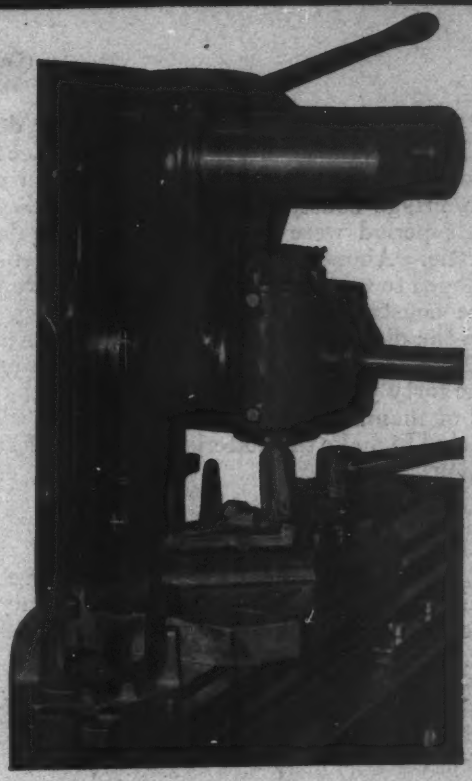
In military performance there is often an advantage in increasing the climb, speed or maneuverability by reducing the fuel load instead of increasing the range or useful load.

Due to the excess air pumping capacity of the Diesel for a rated power, the emergency reserve of power is available for increased altitude performance. The Packard engine is reported to be equivalent in power to a three hundred and fifty H.P. carburetor engine at twenty thousand feet altitude.

Twenty per cent. reduction in fuel consumption and a fuel density increase from .71 to .87 specific gravity results in a thirty-five per cent. reduction in tank size, and nearly as much saving in weight. This saving may be reflected in reduced size and drag of the fuselage.

The practice of running over-rich to provide good distribution, the necessity of careful mixture adjustment in the carburetor, and the required altitude adjustment are all eliminated in the Diesel. The result is that maximum economy is attained without danger of poor distribution, and without constant attention to mixture adjustments.

May this statement of the advantages of the High Speed Diesel accelerate the solution of its problems, and lead to its early utilization in the automotive field.



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Bridges

(*Continued from page 15*)

crude in their construction and defective in detail. The fact, however, that many of them saw service for a long period of years reflects great credit upon early leaders in bridge construction. The materials used during this period were materials which are imperfectly elastic. About 1890 the manufacture of steel had developed to such a point that it became available for bridge construction. Processes of making steel date from the discovery of Sir Henry Bessemer about the middle of the nineteenth century, but it was not until some forty years after these discoveries that the processes of manufacture were sufficiently developed and perfected to make the material available for bridge construction.

Bridges Now Built of Steel

Since 1890 practically all metal bridges have been built entirely of steel. This material not only has great strength and durability, but it is truly elastic.

Courtesy Baldwin Locomotive Works

This railroad bridge spanned the Green River, Kentucky. Built in 1859, it was a wonder in its day. The trusses are of Fink design, a type now obsolete.

The latter characteristic is of immense value to the designer. He has available for use a material which meets all the requirements of abstract theory; and experience and experiment have both proved a close relationship between the physical properties of steel and the laws of elasticity of material. The engineer and designer, therefore, can predict with confidence the behavior of a structure built of steel simply by the application of the scientific principles governing elastic materials. It is not necessary to determine the strength of a steel structure by actual tests of the structure itself. There remain many details of construction which do not lend themselves readily to scientific analysis which still require tests to destruction to determine their true strength. Knowledge of the scientific principles governing the action of such details is constantly being developed and extended, so that now it can be said that there are relatively few parts of a steel structure which must depend solely upon experience and judgment for the purposes of design.

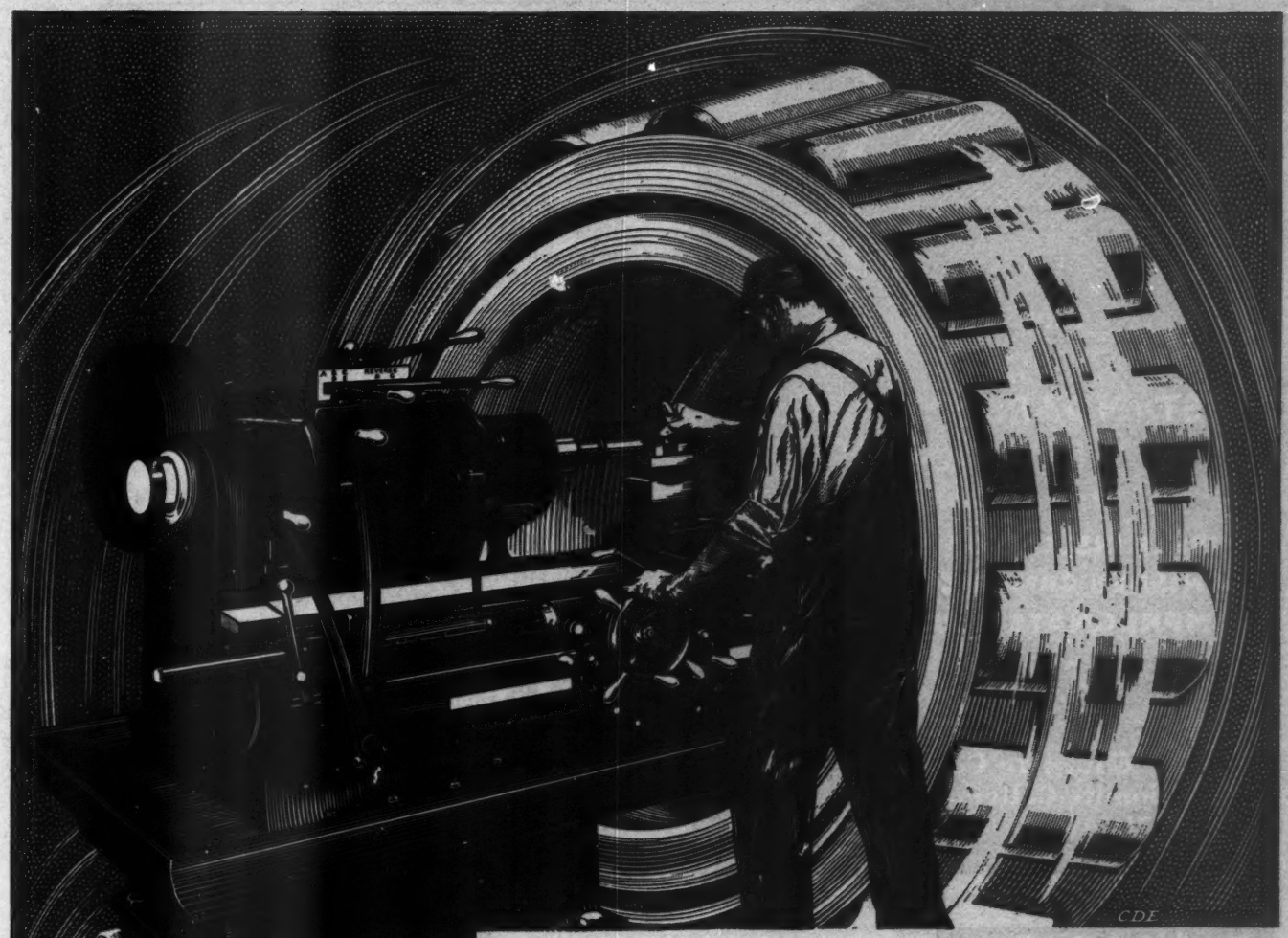
The adoption of steel in bridge construction was coincident with a further growth and expansion of the railroads of the country. Locomotives became heavier and more powerful; cars stronger and heavier. Grades and curvatures of lines were reduced, increasing the length and weight of trains which could be hauled. The earlier bridges were soon found to be inadequate to support the rapidly increasing train loads, and it was necessary to replace them with heavier structures. The growth of locomotive loads and increase in speed of trains, involving heavy impact stresses, was so rapid that even new structures built of steel soon became inadequate for these increasing loads, and not only the earlier mixed type of structures which were built of combinations of wood, cast iron and wrought iron, but many bridges built entirely of steel had to be replaced to meet these heavier burdens. At this time, some forty years after the introduction of steel in bridge construction, there are practically none of the old bridges in service, and relatively few of the early steel bridges, except upon branch lines.

About the beginning of the present century another advance was made in bridge construction with the use of alloy steels. These steels have much greater strength than the ordinary carbon steel and have made possible the construction of bridges of far longer span.

Highway Bridges

At about the same time that alloy steels were beginning to be adopted for bridge construction, the gas engine became available for vehicular power. The rapid development of the automobile industry is familiar to everyone. It has made the highways of the country natural routes for the transportation of heavy loads. The early highway bridges were designed to carry horse-drawn vehicles which were relatively few in number and light in weight. The pleasure automobile and the truck have greatly increased the use of the highways, both in number of vehicles and the weight of loads carried. This has required the replacement of early bridges with heavier structures, and stimulated the construction of long span bridges, particularly in our congested city centers where the volume of street traffic has grown to be a serious problem, and speed and facility of movement imperative to the normal circulation of traffic.

This brief sketch of the development of bridge construction indicates three definite periods in its development. First, the period prior to about 1850 when scientific knowledge was not available for application to bridge construction. All structures built during this early period were the result of trial and error. The second period, the forty years from 1850 to 1890, represents the period of scientific and experimental development. During this period there was a great improvement in building materials, in scientific knowl-



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edge, and the application of both to construction problems. The third and modern period from 1890 to the present day covers the period of truly scientific bridge design and construction. It is of interest to note the interlocking of the various factors that have influenced the growth of bridge construction. First, Galileo and Hooke at relatively the same period of time made discoveries which were along entirely different lines of research, but which were both essential to the development of the theory and practice of the uses of material for construction. Again, at approximately the same time, Saint Venant, Squire Whipple and Sir Henry Bessemer made discoveries which were also all essential to the development of modern bridge construction.

In the Future, What?

No one can say what the future has in store. Steel bridge construction is only forty years old. The use of alloy steels for these structures dates back only about twenty years. There are many unsolved or imperfectly solved problems in steel design. New problems in design are arising every day. There is ahead of us an expanding opportunity for applying these principles in actual construction. Even in the face of the remarkable progress which has been made in steel bridge construction, it would be a mistake to assume that the work has all been accomplished. As a matter of fact, it is only well begun.

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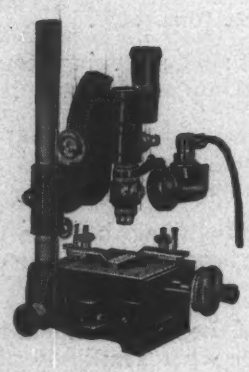

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Astronomical Mirror

(Continued from page 6)

Astronomical Contingents of a 200-Inch Mirror

What will be the actual gain in seeing ability? The light-gathering power of the mirror will be probably not less than four times that of the 100-inch mirror. On account of the greater convenience, however, this factor will undoubtedly be increased. Four times more light, with equal accuracy, means that the distance of reach of exploration is increased twice. That means that our visible universe is thus increased 2 x 2 x 2, or eight times.

Dr. Harlow Shapley, director of the Harvard Observatory, has declared, in published interviews, that much progress will surely be made, with the help of the 200-inch telescope, toward solving the ten major mysteries of the universe: (1) the constant slight changes in the locations of the north and south poles; (2) where the comets originate; (3) why the sun rotates so rapidly; (4) the source of the energy that runs the universe; (5) whether or not the universe is running down; (6) the origin of the meteors; (7) the nature of the dwarf stars near the sun; (8) the magnitude of the nucleus of our own star system; (9) why other galaxies of stars outside our own appear to move away from us so fast; (10) whether or not there is a limit to the explorable universe.

Already, man, in imagination and intellect, possesses one requirement for the probing of such secrets. He will have the other essential factor when he points the new telescope toward the depths of interstellar space

An Industry's Program That Made Front-Page News

Cloth rolling off the looms . . . thousands of yards . . . millions of yards . . . pouring into an already glutted market. Women and children working through the long night hours to produce more goods where less was needed.

From competitive chaos in the textile industry order and straight thinking have suddenly emerged. Through The Cotton-Textile Institute, an agency of the industry's own creation, the end of night work for women and minors has been decreed.

This single step projects on the horizon the following benefits: (1) Full time for the day worker instead of part time for him and the night worker; (2) more orderly production; (3) better working conditions; (4) more profitable operation; (5) better returns for mill and worker.

No wonder textile markets are stronger! No wonder the textile industry is raising its head and its good news is making the front pages!

Underneath all this new progress there will be found, as usual, a McGraw-Hill publication. *Textile World* long ago urged the abolition of night work for women and minors as one step in a program to restore prosperity to textile mills and employees. It has labored side by side with the industry for the achievement of that program.

So in many industries, today, you'll find a McGraw-Hill Publication sponsoring progressive thought and action. If you keep abreast of the day-by-day achievements of the field you expect to enter, read the McGraw-Hill paper covering that field. Most college libraries have, or should have, McGraw-Hill Publications. Ask your librarian.

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Tailor-Made Steels

(*Continued from page 13*)

and their influence on fuel conservation and fuel costs are beyond calculation at the present time.

Hard Steels Overcome Friction

The development of steels to overcome the losses and waste caused by friction and wear also has made notable strides. The surface hardening of special steels by the use of nitrogen is one of the most important metallurgical developments of recent years. Nitralloy steels are case-hardened by nitriding at low temperature, without subsequent quenching, and without deformation or distortion. It is thus possible to machine an automobile gear, for example, to absolutely accurate dimensions, give it the nitriding treatment and secure a surface hardness far greater than that obtainable by any of the older hardening methods. The case of nitrided Nitralloy will scratch glass with ease. Special testing files wear smooth without effect on its extremely hard surface. This steel is beyond the range of the usually accepted devices for hardness testing but its minimum hardness, translated into terms of Brinell numerals, is several hundred points higher than anything obtainable by carburizing.

Bearings of this material can be run-red hot without injury. It is too hard to "seize" a softer metal, even where lubrication is entirely absent. Sliding surfaces thus wear to a perfect fit with virtually no subsequent wear. It is interesting to note that the plane used by Coste and Bellonte on their recent Paris-New York flight was liberally equipped with Nitralloy parts for wear-resistance.

New Developments Rapid

It is exceedingly difficult to draw a general picture of the science of alloying as it exists today. Developments are occurring so rapidly and research is being carried on along such varied lines that the outlook is anything but clear. To date, several general classifications seem to stand out as major lines of alloy development:

1. Alloying for physical properties — strength, toughness, resistance to shock and fatigue, sometimes with a corresponding reduction in weight.
2. Resistance to atmospheric or natural corrosion and to corrosive agents used in process industries.
3. Resistance to high temperatures (called dry corrosion by some metallurgists) with physical properties well retained to permit the use of high pressures at elevated temperatures.
4. Resistance to wear and abrasion.

Each of these represents a tremendous field in itself. The first classification perhaps is farthest along in its development, due to the insistent requirements of the automotive industry over the past ten or fifteen years that steels be supplied which would permit the production of safer, smaller, lighter, higher speed cars. Other industries are availing themselves of the lessons learned in the growth of the automobile.

The "stainless" steels and irons, in a wide number of analyses, are rapidly overcoming many problems in

classifications 2 and 3, though this development is in its early infancy and is believed by some observers to be potentially the most important element in special steel making.

Nitralloy and other materials and processes are making great strides in the fourth field, though many other factors, such as improved lubricants and lubricating methods as well as ball and roller bearings, are working toward the same goal.

The coming year will see intensive efforts of all producers to cultivate markets for the new special steels. The inevitable changes in the consuming habits of steel users is bound to result in rapid shifting of markets, and in obsolescence* and adjustments in production equipment of both the steel industry and those industries which are its most important customers. How rapid and drastic these changes will be is sheer speculation, but there can be little doubt that the steel industry is on the threshold of a decade of development such as it has never seen since the invention of the Bessemer process.

*See article on "Obsolescence In the Iron Industry" in this issue. Page 7.

Departmental Notes

(*Continued from page 20*)

which it is possible to measure harmonics of extremely small amplitude. For the measurement of very small voltages caused by sound, an amplifier has been developed with an amplification factor of about one million. The practicability of apparatus for the production of a standard plane wave of sound, of apparatus for testing electro-acoustical apparatus by measuring the response to a direct current transient, and of apparatus for measuring sound pressures is being investigated.

New Equipment

New pieces of equipment have been installed in various of the laboratories. A new oscillator panel has been installed in the Electrical Communications Laboratory. A mathematically ideal alternator has been obtained for the Machine-transients Laboratory. A sound-proof room has been built in the Technical Electrical Measurements Laboratory. A new safety code is being compiled for issue to students working in the laboratories.

Continuing Researches

Work on most of the researches reported in the previous Departmental Notes for this Department still continues. The Network Analyzer has seen service on a number of problems of academic and commercial interest. The new Mechanical Integraph probably will be finished next term. The Photoelectric Integraph is undergoing improvements for use as the basis for the design of a new model. In the meantime it is being used in a preliminary way for determining periodically and correlations of river flows as an influence on hydro-electric power production. In the Machine-transients Laboratory, methods have been devised for showing the angular displacements of the rotors of alternators by means of motion pictures. The study of the properties of insulating materials carried on in cooperation with the National Electric Light Association now centers about the development of a bridge for the precision measurement of power-factor of small oil samples. The investigation of fog, and the measurement of field intensities with the aid of a dirigible at Round Hill have been completed. The fog investigation resulted in the determination of a theoretical expression from which the amount of absorption of light of a given frequency for given fog conditions can be calculated. The measurements of field intensities are being plotted and compared with similar curves calculated from theory.

In addition to the various researches particularly mentioned, many others are being carried on by staff members and by advanced students.

Courtesy American Machinist

Grinding a 46-ton motor shaft, 34½ ft. long and 31⅝ in. diameter.

Wrought Iron

(*Continued from page 9*)

bloom into the finished products is, however, according to practice familiar to rolling mill engineers.

Finished Product Manufacture

The 40-inch blooming mill which is of the most modern type, is driven by a 5,000 H.P. motor and will reduce the iron blooms into either slabs or billets. It is electrically controlled entirely. From the mill the slabs or billets pass to an electrically driven shear which cuts them into the lengths desired.

The products of the universal plate mill are plates from 12 inches to 84 inches wide, skelp for the manufacture of pipe, and forging blooms or billets.

Two furnaces are now in service for heating the blooms that are fed to the mill. This mill, like the blooming mill, is operated by electrical devices of the latest and most approved type. The slabs or plates pass from the mill to a hot bed and from this to shearing tables where the sides or ends, or both, can be cut.

Parallel to the plate mill, a 20-inch, 18-inch, 16-inch skelp mill has been installed. In this mill will be rolled skelp for the manufacture of pipe of the smaller sizes. The mill is of the type known as continuous. Its operation is unlike that of either the blooming or universal mill in that the bloom being rolled passes from one stand of rolls to another instead of back and forth through one set of rolls. In this mill there are five stands of edging (or vertical) rolls and nine stands of horizontal rolls. The edging rolls exert a pressure against the sides of the plate and do away with the necessity of side shearing. A hot bed 160 feet long receives the skelp from the run-out table.

Adjacent to the mill just described is a mill for rolling billets into merchant mill products, viz: rounds, flats, squares and other sections. Billets to be rolled in this mill are heated in two furnaces of a design similar to those that heat slabs for the universal and skelp mill.

The billet is first passed through one stand of roughing rolls and then through five stands of finishing rolls. An 800 H.P. motor drives the roughing stand; one 800 H.P. and one 1,200 H.P. motor drive the finishing stands. The product may go through a rotary flying shear to a 110-foot hot bed, or to two reels. Two roller tables carry the rods to vertical shears through which they pass to bundling tables.

Obsolescence

(*Continued from page 7*)

pig iron per day. But these furnaces are all gone.

Beehive coke from the Connellsville region of Pennsylvania became the standard blast furnace fuel of the country in the eighties, and held the lead over all other fuels until after the World War when by-product coke took the lead and is now practically the only blast-furnace fuel used in the United States.

With the passing of these blast-furnace fuels — charcoal, anthracite, stone coal, beehive coke — practically all within a span of 50 years, there was complete and costly obsolescence of whole blast-furnace plants as well as of the plants that produced the fuel, and the means of transportation. In the case of anthracite and stone coal other uses were found, but in the case of charcoal and beehive coke there was the wiping out of many small communities, and the decay of long rows of beehive coke ovens.

Not only are the owners of the iron works heavy losers in such obsolescence, but the business men of the vicinity are effected. In some cases transportation lines are left without traffic. Whole states suffer from industrial depression when the smelting of iron ceases within their borders. For instance, the state of Virginia was an important producer of iron for two centuries, and made millions of tons of charcoal and coke pig iron from her native iron ores. Her blast-furnaces are dismantled and her iron mines awaiting new processes or a shift in economic conditions.

New Methods Bring Revival

The New England States were all pioneer iron makers, but the industry died out completely until progress brought about the condition whereby a blast-furnace became a part of a manufactured gas system and could be supplied with tide-water foreign iron ores.

The blast furnace of the Mystic Iron Works in Boston Harbor is an example of the revival of an iron industry by combining the advantages of the geographical location with the available means of transportation, all tied up with the advance in the methods of making blast-furnace fuel.

Other regions of the country have experienced a revival of their iron industries by making the right combination of their available markets, transportation facilities, sources of iron ores, and the proper arrangement of their blast-furnace fuel in some by-product

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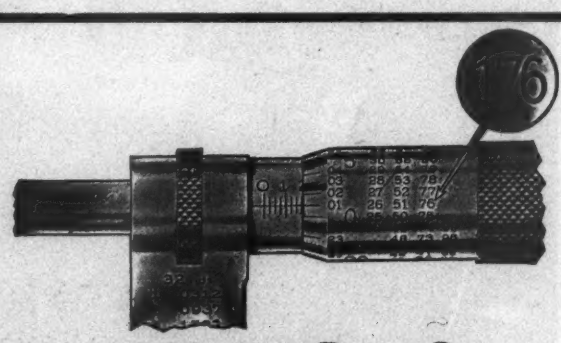

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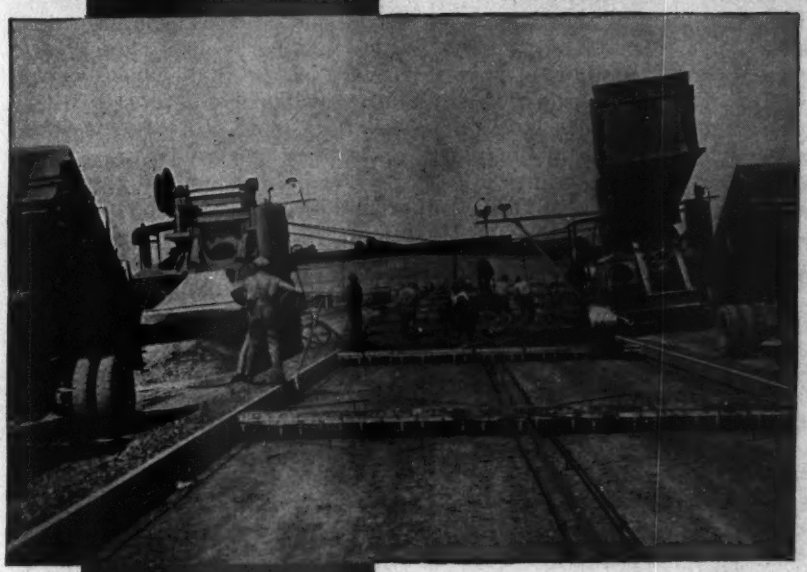

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WRITE FOR BULLETIN TELLING ABOUT THE RANSOME MASTER PAVER

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system. Blast-furnaces along the Ohio River are now making iron from ores carried by rail and water for hundreds of miles and using fuel made from coal shipped by barge to by-product coke ovens.

Even the obsolete blast-furnace fuels might be revived under certain conditions. A modern charcoal blast-furnace has recently been erected in India where there is plenty of iron ore and wood for charcoal. There are places in this country and Canada where charcoal pig iron could be made providing the market for the iron was sufficiently assured.

Anthracite passed out as a blast-furnace fuel before the process of blast-furnace practice was sufficiently advanced to get the best results from such a dense fuel. In those days the combustion zones at the tuyeres had not been explored and bounded and the big lumps of "steamboat" coal fitted into the practice of using big lumps of ore and limestone. A blast-furnace with modern equipment and properly sized anthracite might revive anthracite as a blast-furnace fuel in certain restricted areas.

Iron-Making Advances Thousandfold

The advance in the art of making pig iron amounting to a thousandfold measured in tonnage of daily production is strikingly illustrated in comparing two blast-furnaces that I visited in August and September of 1930. One was the ruins of Argillite furnace on the west bank of Little Sandy River in Greenup County, Kentucky, built in 1818 with a capacity of one ton of charcoal iron per 24 hours. The other was No. 4 furnace of the Jones and Laughlin Steel Corporation at the Aliquippa plant in Beaver County, Pennsylvania, making over 1,000 tons of pig iron in 24 hours. The primitive little charcoal furnace in a secluded valley of Kentucky about 8 miles back from the mouth of the Little Sandy River where it empties into the Ohio was only one of scores of charcoal blast furnaces that flourished in the Hanging Rock Region, giving work to several thousand men for over half a century. Back in the seventies this region produced nearly one-fifth of the charcoal iron of the country. This whole charcoal iron industry was obsolete and abandoned by 1892. The single modern blast-furnace now at Portsmouth, Ohio, will make as much iron in six months as the whole Hanging Rock Region made in a year 50 years ago.

Much more could be said about the obliterating price of progress in the making of iron, but this is enough to show how severe has been the obsolescence. This side of the iron industry has been forgotten whenever the iron makers ask for a small protective tariff on pig iron "in pigs," and only the gigantic size of the steel plants is seen by the politicians and the newspaper writers of superficial knowledge of the iron making history of this country. In the winter of 1929 several Tech graduates were before the Committee on Ways and Means trying to get enough duty to protect the blast furnaces of the Atlantic seaboard and Middle West from the low-cost pig of India, Great Britain, and Continental Europe. They had wonderful success and under the flexible tariff law they were granted the full limit of increase, 50%, amounting to 37c added to 75c! The iron makers have borne the costly obsolescence, they have seen the scrapping of their former record-breaking blast-furnaces, but they have not yet introduced a bill into Congress for the relief of an industry whose raw materials are depleted as soon as smelted and whose plants are periodically completely obsolesced.

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Hoover Dam

(*Continued from page 11*)

Colorado River Discharge

The Colorado River at Boulder Canyon has a mean annual discharge of 15,700,000 acre-feet, with a variation of from one-fourth to nearly three times the mean. Hoover Reservoir will have an initial capacity of 29,700,000 acre-feet with water surface at the spillway crest, or 30,500,000 acre-feet with water surface at elevation 1,229, three feet below the crest of the dam. 9,500,000 acre-feet will be reserved for flood control, and the remainder will be used for irrigation, power, and silt retention. With almost certain construction of additional dams upstream in the near future, it is estimated that silting will decrease the reservoir capacity by not more than 3,000,000 acre-feet in fifty years, and this loss will be offset by the decreased flood control capacity required. Primary power output is estimated at 663,000 H.P. at the outset and 594,000 H.P. at the end of fifty years, the decrease resulting from upstream depletion by irrigation.

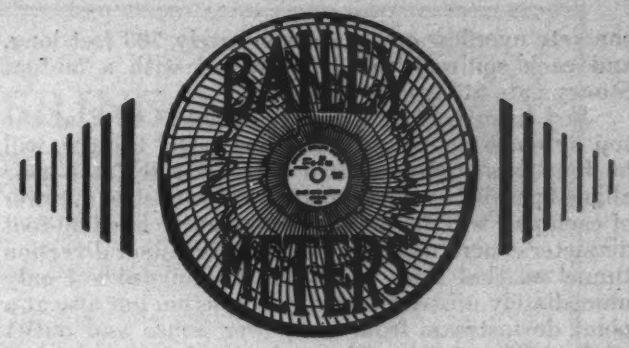
The approximate dimensions of the dam, according to tentative design, will be as follows: maximum height above foundation rock, 725 feet; maximum base width, 650 feet; top width, 45 feet; length at top, 1,180 feet; radius of curvature of axis, 500 feet. It will contain approximately 3,400,000 cubic yards of concrete.

Hydrostatic uplift in the foundation and in the concrete of the dam will be minimized by a cut-off trench, grouted at 5-foot intervals, and a drainage gallery in the dam which will receive seepage through drill holes into the foundation and abutment rock and through porous concrete tile drains in the dam, and deliver it to the downstream face through radial galleries.

Four Tunnels to be Bored

To pass the river during construction, four 50-foot diameter concrete lined tunnels, from thirty-five hundred to more than four thousand feet in length, will be bored through the canyon wall abutment rock, two on each side and all in the same horizontal plane. The water will be diverted through these by the upstream cofferdam, and the downstream cofferdam, which will be protected from turbulence by a rock barrier, will keep the tailwater out of the foundation excavation. Both cofferdams are to be of the earth and rockfill type, and the upstream face of the upstream cofferdam will consist of reinforced concrete paving overlying a rock blanket and sealed to steel sheetpiling at the upstream toe. With a freeboard of 13 feet on the upper cofferdam the tunnels will discharge 200,000 second-feet, which is slightly less than the twenty-year flood. This conservatism is justified by the desirability of limiting the headwater elevation to one which would not cause a disastrous flood in the event of failure of the upstream cofferdam, and the desirability of minimizing the possibility of interruption of work during a normal flood season.

When no longer required to bypass the river, each of the outer diversion tunnels (those away from the river) will be connected to one of the two spillways by an inclined 50-foot diameter concrete lined tunnel, and plugged immediately upstream from the junction. The spillways, as tentatively designed, will consist of concrete lined open channels parallel to the axis of the river, one in each canyon wall, their sides capped with



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concrete overflow crests approximately 700 feet long, and each spillway will be provided with a 50-foot Stoney gate at its upstream end.

Just upstream from the dam, linked to it at the top by concrete encased structural steel bridges, will be four intake towers, two on each side, each pair aligned parallel to the river axis. The upstream tower of each pair will discharge through an inclined 30-foot diameter concrete lined tunnel into the inner diversion tunnel on that side, which will be plugged not only immediately upstream from this junction but also at a point downstream from the power house and outlet works. The outlet works on each side will consist of two groups of eight 72-inch needle valves, each valve in line with an emergency outlet gate, and each group housed in a building in the canyon wall, the one above the other, downstream from the power house, except that these will be supplemented by four needle valves and outlet gates in the downstream tunnel plug. Half the lower and upper canyon wall outlet works on each side will be supplied by the revamped inner diversion tunnel, as well as half the number of power penstocks. The remainder of the outlet works and power penstocks on each side will be supplied by a 30-foot diameter concrete lined horizontal tunnel leading from the downstream intake tower. Thus the power units and outlet valves are combined in four independent groups, so that de-watering of any intake tunnel will decrease the plant capacity by only 25%.

Power House Below Dam

The power house is to be a U-shaped structure, the central portion founded on the downstream toe of the dam, and the wings extending downstream along the canyon walls. Two passenger elevators in the dam, in addition to the inclined freight elevator in the Nevada canyon wall, will provide access from above. All the generator units will be housed in the wings, half the number in each. Probably there will be between twelve and sixteen units altogether, but agreement as to size and number has not yet been reached.

It is contemplated that construction of the diversion works will be started in April, 1931, that the project will be completed in seven years, or in April, 1938, and that by September, 1936, enough of the work will be finished to permit storage of water to elevation 935 for operation of six of the power units. From that time on power for construction, as well as for distribution, will be supplied by the power plant. Before that time construction power will be supplied from San Bernardino or Victorville, California, some 240 miles distant.

Boulder City will contain residences for Government officials and employees, Government offices and also contractors' offices and quarters for contractors' employees. Because of the belief that the tremendous dam and the 115-mile lake, located in a region of scenic splendours, will attract tourists and so prevent the town from dying after completion of construction, it was decided not only to make it a permanent town but also to make it a model city. Water supply and sewerage systems, which will be necessary in any event, have been tentatively designed, and an architect engaged as city planner. However, there is some question as to the ultimate growth of the community, and final plans have not yet been decided upon. A possible solution is the construction of the town piece-meal, according to immediate needs, but following the plans now laid out.

As shown in the Colorado River Board report of November 24, 1928, the estimated cost of the Boulder Canyon Project, including the All-American Canal but not the Coachella branch, is $165,000,000, of which $108,800,000 is for the dam, power plant and appurtenant works.

The Mathematical Bee

Several hundred years ago a lively discussion took place among scientific men as to the mathematical correctness of the cells of a honeycomb. As a result of the discussion Reaumer, the famous French physicist and member of the French Academy, offered the following problem for solution: "Construct a six-sided vase with sides of rhombic form. How great should the angles be to provide maximum of space with minimum of material?" Many scientists tried to solve the problem, and finally a German mathematician, Konig, found that one angle of the rhombus should be 109° 26′, the other 70° 34′ (together, 180° or two right angles).

But one architect persisted in making his with angles 109° 28′ and 70° 32′. That architect is the bee. Scientists, noticing this, finally began to doubt the correctness of Konig's calculations and began to do some more figuring. A Scotch scientist, McLaurin, verified Konig's calculations, as did also Reaumur, although they could not understand why the bee should not use these angles.

The truth of the matter was discovered quite unexpectedly. A ship had gone on the rocks, and when the authorities began to look into the cause of the disaster, they found an error in the table of logarithms which the captain had used in calculating the course of his ship. The logarithm table was the same one that the great mathematicians had used in solving the problem of Reaumur. They began to figure again and then found to their surprise that the bee is right, and that when she builds a cell with angles of 109° 28′ and 70° 32′, she uses the minimum amount of material and gets the maximum amount of space.

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Again people talk excitedly of "burning air"

When a public display of gas lighting was given in London in 1802 to celebrate the Peace of Amiens, people talked excitedly of burning air. Napoleon called it a grand folly, and Sir Walter Scott wrote that the world was going mad.

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